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GENERAL-CARGO DOCKS

THE efficiency of the dock industry can affect the living standards of everyone in Britain. In his article 'Electrical requirements of general-cargo docks' on p. 304, Mr. E. R. Radway discusses among other things the electrical supply and distribution practices of the industry, the electrical features of the pumping plant, and the requirements for tenants and the safety of shipping.

Mr. Radway's article was written with special reference to the South Wales ports, and the cover illustration this month shows a general view, looking north, of Newport docks

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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ENGINEERING WRITING AND SPEECH

'How strong an influence works in well placed words' observed George Chapman. The writer is a creative artist, whatever the form of his creation, be it prose or poetry, a recital of an emotion by a sentimentalist, a dreamer's fantasy—or the description of a development or an application by an engineer.

The speaker also is a creative artist. By studied intonation, by the excellence of his enunciation, and by the force of his eloquence, he can contrive to grace with charm a speech that may be designed to challenge, to protest, to praise or to applaud. The engineer by and large makes a better speaker than writer. Perhaps it is that the direct, practical approach of speech seems inappropriate when his pen is in his hand.

But the work of the engineer must be presented well, in speech or on paper. Failures in expression can easily result in a devaluation of the whole effort, its preparation and potential, and an ultimate lack of appreciation by the reading or listening 'public'—using 'public' to mean the particular audience, large or small, lay or special, to whom the written or spoken word is directed. Apart from the proper handling of the English language—preferring the straight blunt phrasing of our native tongue to the over-elaborate and over-subtle accretions of recent times—there is the awful ailment of ingrowing specialization where initiation into a new mood or a new terminology seems a prerequisite to communication.

With a subject like engineering—replete enough with specialist terms and phrases—simplicity, clarity and conciseness are vitally important and should always be the goal. It is surprising how often referees in their assessment of a paper agree unanimously that the facts and content are all that could be desired but that further thought must be given by the author to form and presentation.

Good writing and speaking, like all other human skills, whether practised in a laboratory, in a manufacturing organization or elsewhere, are the fruit of study and exercise.

When all is said and done, and a great deal has been said on this matter, are the skills of good engineering writing and speech so very hard to acquire? Is there, should there be, such a thing as *engineering* writing and speech? Should not we be content with that natural facility in the handling of English that comes from reasonable practice? Is it not the existence of systems, techniques and vogues that hampers the budding practitioner in the development of a good and fluent English style of writing and speech?

In this regard, hear Faraday's advice to a lecturer*: 'A lecturer should appear easy and collected, undaunted and unconcerned, his thoughts about him and his mind clear for the contemplation and description of his subject. His action should be slow, easy and natural . . .'. Again, 'A lecturer should endeavour by all means to obtain a facility of utterance and the power of clothing his thoughts and ideas in language smooth and harmonious and at the same time simple and easy'.

How simple and acceptable is the advice of one whose manner, according to Bence Jones his biographer, 'was so natural that the thought of any art in his lecturing never occurred to anyone'.

Yet modern advice on how to speak and how to write, flooding from the presses, is far more complicated, much more abstruse. Is there not a danger that all this instruction may inhibit the budding writer or speaker and prevent his practising the natural flow of expression, by making him think that the whole business is very difficult?

Of course, there are vested interests at work, openly stating that it *is* all very difficult and that investment in this or that book, in this or that course of lessons, will remove all the difficulty. The recipient will get rid of his mental rigidity; change a brooding, introspective attitude to expansive participation in conversation and affairs; learn how to describe with freshness and vigour; extend his vocabulary; and so on.

Fortunately, the average engineer is unlikely to wander into those by-ways. But he may often be puzzled by all the conflicting advice he receives on the use of words from well meaning people whose interests could hardly

* 'Advice to a lecturer' (Royal Institution, 1960)

be described as vested. We all suffer from the pedants—the word-banners—who would keep the English language in chains and deny it free development and enrichment from many sources.

But are not the attempts more serious that set forth writing and speech as specialized techniques with a rigid pattern of rules and regulations as to application in this circumstance or that? This comment illustrates the approach: 'Of primary importance to engineers who hate to write (reports, for example), but are required to by their employers, would be ABC-type do-it-yourself instructions for accomplishing this detested chore not only quickly but also in a manner that would produce understandable, informative writing'.

Then there are the vogue words, the U-words, the mannered words, the 'slovenly colloquialisms', 'the low-class illiteracies', the 'clichés', 'the marks of little intelligence', 'the dreadful variations'—epithets that seem to suggest that, as in *My Fair Lady*, 'an Englishman's way of speaking absolutely classifies him'. Can it be that in England, the land of the language, the aspiring author or writer finds a thousand secret inhibitions putting a stop on his vocal cords, a brake on his pen?

Let him take courage—it is not yet an indictable offence to split an infinitive or to use a 'bad, ugly and quite unnecessary word'. He will not be hauled before a court of letters if he fails to avoid the pitfalls of 'situational notation and subjective perspective'. Of course, there are many valid rules for good English, but it may be best to have as few prejudices as possible and to build one's own individual style, by assiduous practice and study, on the austere foundations of a natural, direct intent. 'If you wish to be a good writer, write' said Epictetus, and we might add 'write for meaning, not for effect'.

It is said that Sir Winston Churchill laid the foundations of his great career as a writer and debater in the debating societies that he attended in his youth. These were organized to be free and not under the influence of time-tables and curricula. Lloyd George would debate on anything and at any time in his uncle's shoe-repairing shop and the chapel vestry.

It is sometimes suggested that engineers are too narrow in their outlook and that they might well recall the activities of the Lunar Society in Birmingham in the 18th century, or again the Smeatonian Club of London fame. The engineering members of those societies wrote and talked about all subjects. Fortunately, we live in an age when freedom of expression is a cherished heritage, though as we believe not enough people make use of it. There is no need for the engineer to suffer 'butterflies in the tummy' any more than the politician or the lawyer. He too has a crusade, an aspiration, and in what he has to write and say oft-times lies the hope of centuries.

To end with a note from R. L. Stevenson: 'Bright is the ring of words when the right man rings them'.

THE ENGINEERS' GUILD

DURING recent years there has been some evidence of misunderstanding of the purposes for which The Institution of Electrical Engineers is established and a corresponding lack of appreciation of the functions of the Engineers' Guild.

The Royal Charter under which The Institution is constituted makes it clear that The Institution is established to promote the general advancement of electrical science and engineering and their applications. The means by which The Institution seeks to achieve this object are various, but generally speaking consist of the creation of conditions in which knowledge is spread and advanced. What may broadly be called 'protective activities' are, however, outside the scope of The Institution.

The Engineers' Guild, on the other hand, can and does properly concern itself with the protection of the interests of members of the profession. Its activities are therefore separate from, but in a sense complementary to, those of The Institution. Its membership is drawn exclusively from members of The Institution of Civil Engineers, The Institution of Mechanical Engineers, The Institution of Electrical Engineers and The Institution of Chemical Engineers, and those who wish to support any collective action expressly intended to advance the interests of professional engineers are entirely free to join it.

SCIENTISTS AND TECHNOLOGISTS

THE Deputy Secretary of the Ministry of Education, Mr. Antony Part, stated recently that an annual output of at least 20000 scientists and technologists, which the Government adopted as an objective for 1970, would be reached at least five years ahead of time. This would be double the output in 1956.

The technical colleges in England and Wales, which produced about 5000 scientists and technologists in 1956, would be producing over 9000 by the mid-1960s. Most of those who qualified from the technical colleges five years ago had taken part-time courses; by mid-1960 a much higher portion would have taken full-time or sandwich courses.

A total of 5000 students, including 140 women, were now studying for the Diploma in Technology. Of the first-year students in the present session, 1250 had passes at the General Certificate of Education Advanced level and 450 held the Ordinary National Certificate.

The three main aspects of sandwich courses were first, the links with industry, which to forge successfully needed a lot of time and tact; secondly, the students, who found the mixture of academic study and industrial training much to their liking; and thirdly, the tutorial system, which was one of the most important developments in technical colleges in recent years.

656.11:621–52

ELECTRONIC CONTROL OF HIGHWAY VEHICLES

This article describes the vehicle-control system at present being developed by the author's research organization in conjunction with a major United States car manufacturer. During a visit to Britain in July 1960, the author gave a lecture on the system to the Road Research Laboratory of the Department of Scientific and Industrial Research who are also experimenting with this method of control. Mr. Flory is at the RCA Laboratories, Princeton, New Jersey, U.S.A.

L. E. FLORY, B.S.(E.E.)

THE increasing toll of human life and property damage owing to motor-car accidents, together with the need for increased efficiency in highway utilization, have led to an investigation of ways in which electronic techniques might be used to control individual highway vehicles. The aim is to remove, so far as possible, the human element in acquiring information, making decisions, and instituting action. This would tend to eliminate the reaction time of the driver from the operation of driving.

It is proposed to employ electronic methods to improve communication between the road and the driver, and between two vehicles; to introduce warning systems that will communicate a danger signal to a driver if he neglects to make a decision in time, or if he makes a decision that would put him in an unsafe position; and eventually to take over a portion or all of the control of the car, either full-time or in an emergency, if the driver fails to take proper action.

Limited-access highway

A comprehensive system has been designed which could be introduced on a gradual basis while maintaining complete compatibility with existing traffic. In the interim, certain elements of the system may be used independently to provide increasing safety as the system grows and long before it could be hoped to have complete control in operation.

Considering a limited-access highway or motorway, a single lane of traffic with no passing requires only two functions from the driver. First, he must stay in his lane and, secondly, he must not collide with a car ahead of him. In this oversimplified situation, an automatic means for keeping a car in its lane and a means for preventing collision with a car ahead provide the elements of a complete control system.

The proposed control system comprises two basic elements: an arrangement of circuits for detecting vehicles and generating a signal indicating their presence, and a guidance wire to provide a steering signal.

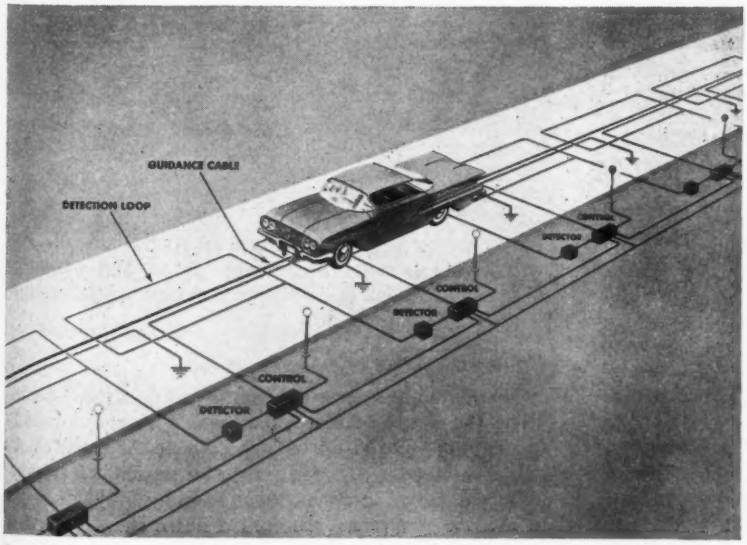
Detection system

The detection system consists of a rectangular wire loop, approximately car-length, embedded in or near the surface of the road and connected to a transistorized detection device which would normally be placed below ground level at the edge of the road.

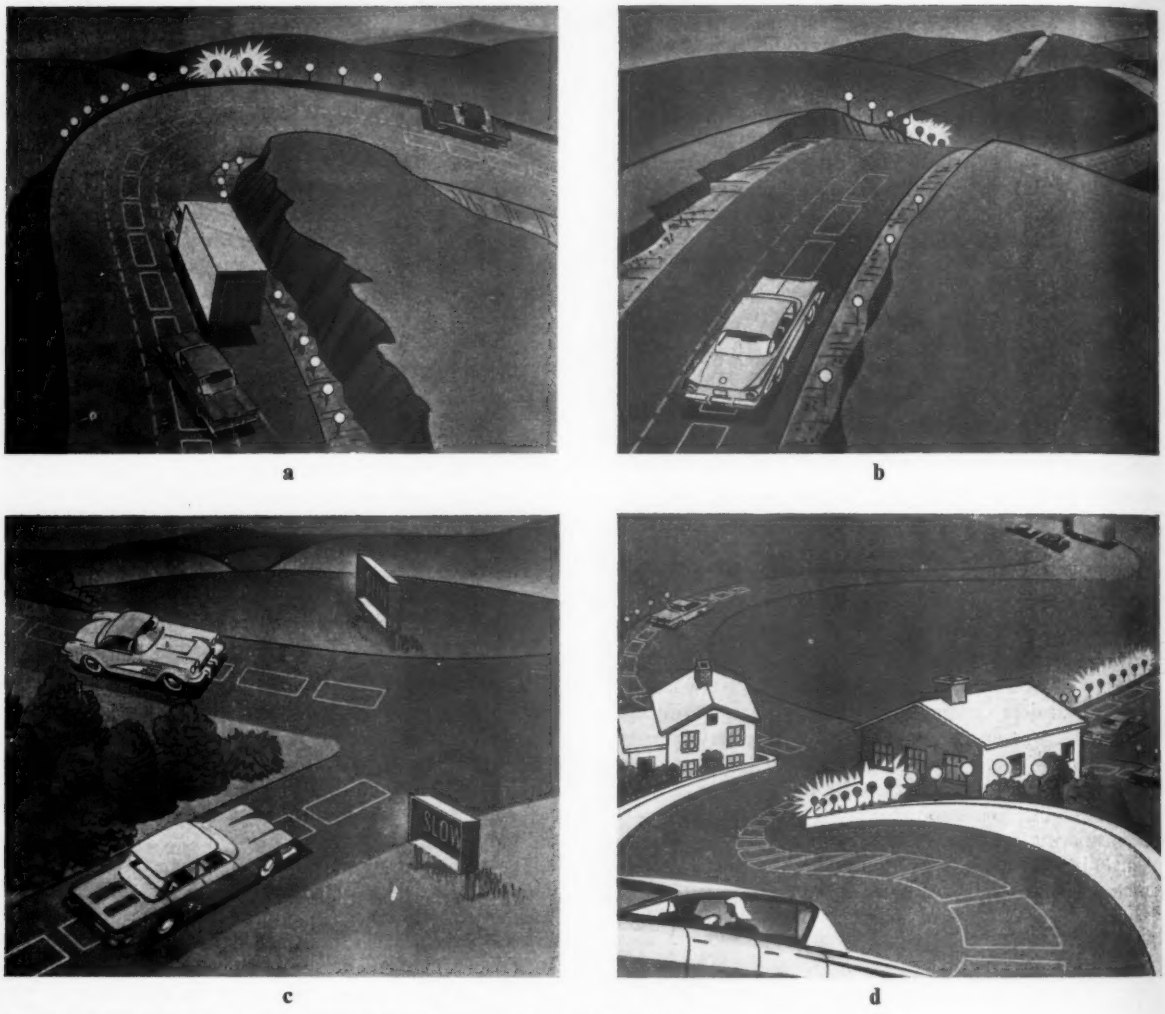
The detection system is based on the phase characteristic of a parallel-tuned resonant circuit driven by an r.f. current generated in the detector. The loop buried in the road carries a small electric current. When a vehicle passes over the loop, the metal in the vehicle causes an electrical variation, which is passed from the loop to the detector circuit at the edge of the road. This causes the detector to generate a signal which can be used for any desired function.

Using these detection elements as a building block, it is possible to perform many individual traffic and safety functions that now require various types of equipment, and to construct an extensive system for fully automatic driving over long stretches of highway. In all cases, the function begins with a signal generated by the passage of a vehicle over the buried loop.

In the ultimate highway system, the loops are placed one after another along the length of the road, spaced closely enough so that a car is always partially



1 *Detector loops and guidance cable embedded beneath the road surface*
The detector and control units are positioned along the verge



a b c d

2 *Locations where advance warning might be given of other vehicles ahead*
a Curve **b** Hill **c** Merging traffic **d** Blind corners Road detectors are connected to a series of signal lights

over at least one loop. The signal from the detector is fed into a network connecting all the detector units along the traffic lane. The resulting signal appears in the system behind the car, becoming weaker at each succeeding detector. The distance that it extends behind the car can be arranged to suit the speed limit on the road and the speed of the individual car.

The signal in the road behind each moving vehicle forms an electronic 'flying tail' that can be used to operate a chain of lights along the edge or down the centre of the road as a visual warning to following cars in foggy areas or in other conditions of poor visibility. As special receiving and control equipment is added to cars, the flying tail of signals can supply information to operate visual or audible indicators within the car and, in the fully developed system, the brakes and accelerator. The complete system will keep cars automatically at a safe driving distance behind those ahead, and cause cars to stop when there is an obstruction or a parked vehicle in the traffic lane ahead.

Guidance system

The guidance system consists of a single cable buried along the centre of the traffic lane. A signal current in this cable is picked up by two coils at the front of the car, mounted at equal distances from the centre-line. If the car moves in either direction away from the centre of the lane, the signal becomes stronger in one coil than in the other, generating a difference signal that can be used either to warn the driver by lights or an audible

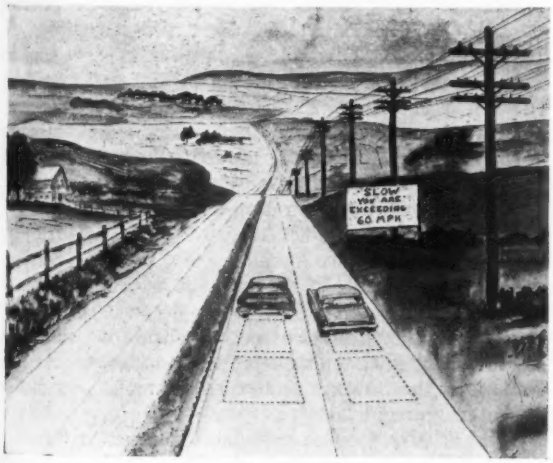
signal, or to operate the steering gear automatically to keep the car centred in its driving lane.

A schematic representation of the highway installation is shown in Fig. 1. Once such an installation was made, it could begin immediately to provide useful signals by means of lights, with no additional equipment in cars. Besides the obvious use of warning lights in foggy areas, many other conditions of restricted visibility would lend themselves to improvement by the installation of such a dynamic warning system. Fig. 2 illustrates some of these areas.

As more and more such installations were made, they could be integrated into a more complete system making it more advantageous for motorists to provide in-car equipment to obtain further benefits. Another immediate application of the principles of the system could provide personal- and active-speed warning as indicated in Fig. 3.

As the system expanded, not only light signals but also electromagnetic signals would be radiated within the flying tail of the system. These signals would contain information giving the headway to the car ahead and the speed of the car ahead. On sections of highway so equipped, a car provided with the necessary receiving and control equipment could be operated automatically to adjust its speed and spacing to take account of the action of the car in front.

An installation demonstrating this possibility has been made in the United States. A ¼-mile track has been equipped with all the electronic devices needed for the complete system, including spacing and speed control as well as automatic steering. Two completely equipped



3 *Road detectors employed to indicate excessive speed*

cars operate from the signals provided by this track. The two cars can be operated independently with no interference, and can also be operated with a third unequipped car operated at random on the track. No action on the part of drivers of the controlled cars is necessary. Operation is quite smooth even on emergency stops. It demonstrates dramatically that the system does provide a means for complete control.

We are certain that some type of electronic control of individual vehicles will eventually be necessary. After seven years of work with the present system, we are confident that we have the elements of a workable system which awaits further tests in actual highway installations.

Summary

In order to reduce the mounting vehicle-accident rate and to make more efficient use of available highways, an automatic system for controlling motor-vehicle traffic is clearly indicated.

The method described could be introduced in a series of progressive stages. Initially, the intention would be to warn the driver in selected locations when a dangerous situation was developing, and to indicate the action he should take. Afterwards, the system could be extended to provide completely automatic control of vehicles over suitable sections of national motorways.

POST OFFICE PROSPECTS

A RECENTLY published White Paper 'Post Office prospects, 1961–1962' (Cmnd. 1327) sets out plans of the British Post Office for the year. For example, improved machines for code-marking letters and for sorting them automatically are being developed.

About 100 of the remaining 820 manual telephone exchanges will be converted to automatic working during the year. By March 1962 about 300 exchanges, serving 1 250 000 subscribers, will have subscriber-trunk-dialling facilities. Tests will begin by autumn 1961 on the first electronic telephone exchange in the United Kingdom, at Highgate Wood, London.

Autumn 1961 will also see the bringing into service of the new telephone cable between the United Kingdom and Canada (Cantat) and the laying of the first telephone cable between the United Kingdom and Iceland. The manufacture of an additional transatlantic telephone cable to link the United Kingdom and the United States will start during the year.

The Post Office will co-operate with the United States National Aeronautics and Space Administration (N.A.S.A.) and the French Centre for Telecommunications Studies in a programme for testing communication satellites. Ground stations will be built in England and France for the reception and transmission of telephone, telegraph and television signals across the Atlantic using satellites to be launched by the N.A.S.A. during 1962 and 1963 in projects Relay and Rebound. These are research and development projects to demonstrate feasibility, basic concepts and technological approaches and to evaluate various systems to be employed in communication satellites.

Project Relay, due to be launched in 1962, is a low-altitude active-repeater satellite and will weigh less than 100 lb. The satellite will contain instruments for detection of radiation damage and other effects of space conditions on critical components, in addition to equipment for communication experiments. Project Rebound is a sequel to N.A.S.A.'s first passive-reflector communication-satellite programme, Echo. The first launching will be in 1963.

André-Marie Ampère: the Newton of electricity

92 (Ampère):621.014.32

Ampère was one of the founders of the profession of electrical engineering. It was he who developed a complete theory of the laws governing the electrodynamics of steady currents which, to quote Maxwell, was 'perfect in form and unassailable in accuracy, and it is summed up in a formula . . . which must always remain the cardinal formula of electrodynamics'. This article is the third in a series devoted to the great men of electrical engineering. The two earlier articles discussed the contributions and lives of Ohm and Cavendish. The author is in the Department of Engineering, University of Cambridge.

P. HAMMOND, M.A., MEMBER

It is one of the happy characteristics of great men that they are ready to praise the work of others who are less gifted than themselves. It is pleasant to find Faraday's courteous reference to the experiment of a certain William Jenkin, who but for Faraday would by now have been forgotten. Maxwell, too, was always ready to give praise, but when he wrote about Ampère his words were not merely the result of courtesy; one feels it was genius saluting genius.

He wrote: 'The experimental investigation by which Ampère established the laws of mechanical action between electric currents is one of the most brilliant achievements in science. The whole, theory and experiment, seems as if it had leaped full grown and full armed, from the brain of the "Newton of electricity" '.

It began with Oersted

Brilliant is the right word for almost everything that Ampère did, and the research about which Maxwell wrote was his crowning achievement. On the 4th Sepber 1820, Arago, one of the permanent secretaries of the French Academy of Sciences, spoke at a meeting of that society about the startling discovery by the Danish physicist, Oersted. For years, scientists of all countries had been looking for a connection between electrical and magnetic phenomena. Oersted at last had put his finger on it: the magnetic effect was associated with electric currents and not with static electricity as so many had supposed.

Moreover, the magnetic effect was not along the conductor as Oersted himself had at first thought, but was disposed in circles about the wire. Arago had heard of the discovery while he was in Switzerland. His announcement to the Academy in Paris caused a great stir among the members. They begged him to arrange a demonstration of Oersted's experiment, and when he did this on the 11th September, everyone attending that meeting realized that a turning-point had been reached in the history of science.

Among the members present was Ampère. He did not stay to discuss the matter, although normally he loved discussion. He went straight home and thought. Urgent letters remained unanswered, all other business was an impossibility: he had to ponder on the experiment that he had just seen.

Oersted had ascribed the deflection of the magnet to a field of action around the wire, but Ampère would have none of that. He was a follower of Newton and all this talk about vortices in the aether seemed to him nothing but an echo of the outmoded philosophy of Descartes. No, what was needed was to discover the action between circuits.

The great discoveries

If a current acts on a magnet and a magnet on a current, would it not be reasonable to assume that a current would act on another current? Reasonable, yes, but by no means inevitable. After all, a magnet acts on soft iron and soft iron on a magnet, but soft iron does not act on another piece of soft iron.

Ampère realized that thought could carry him no further: an experiment was needed, and he hurried out to get a battery and some wire. So it came about that, a week after the demonstration of Oersted's experiment, a paper was read to the Academy by A.-M. Ampère which stated that two parallel wires carrying currents attracted each other if the currents were in the same direction, and repelled each other if the currents were in opposite directions. For good measure it added that all magnetic phenomena were due to electric currents and that there were molecular current-loops inside magnetic materials.

A week later Ampère read another paper, a fortnight later a third, a fourth a week after that, a fifth a fortnight later, a sixth after a week, and three more papers during the weeks following. Within three months of having heard Oersted's discovery, Ampère had developed a complete theory of the electrodynamics of steady currents. To quote Maxwell again: Ampère's work was 'perfect in form and unassailable in accuracy, and it is summed up in a formula from which all the phenomena may be deduced, and which must always remain the cardinal formula of electrodynamics'.

The universal genius

This breathless series of brilliant investigations which he made in the autumn of 1820 is Ampère's sure title to being considered a great scientist. But he was not only a great scientist; André-Marie Ampère was a genius, one of that very small group of men down the ages who achieved more than would appear possible to mortal man.

Consider the range of his intellect. His earliest published work was in mathematics, and here he made important contributions to probability theory, to the calculus of variations, to the study of partial differential equations, and to analytical mechanics. In chemistry he developed independently the hypothesis usually attributed to Avogadro, whose work was not then known in France. He clarified the relation between atoms and molecules, was the first to examine the properties of chlorine and iodine, and wrote on kinetic theory.

In optics he studied double refraction, and in biology he lectured on the relations between species. In philosophy he wrote an important work on the classification of sciences and discussed metaphysical questions with a large circle of eminent men. As a young man he was a keen botanist and, on his botanical excursions, used to recite Latin and Greek poetry, two languages which he had taught himself. His letters show a keen interest in political and economic questions and reveal yet another aspect of the man in his devotion to the Christian faith and his desire to share this faith with others.

He was widely read, loved literature and himself wrote moderately good verse. Equipped with a superb memory, he was able in old age to recite complete sections of Diderot's vast encyclopedia which he had read as a boy. When he died, there was no branch of human knowledge which he had not in some measure made his own, and when he talked with his friends he spoke (in the words of Sainte-Beuve) 'as a blind seer of old would have spoken, if that seer had come after Newton'.

There is no doubt about it—Ampère was a genius.

The early years

He was born at Lyon on the 22nd January 1775, the son of a retired businessman. He had two sisters, one of whom died while he was a boy. The family moved to the little village of Poleymieux soon after the birth of André-Marie and he was reared in the freedom of the countryside, but when the French Revolution broke out, father Ampère decided to move back to Lyon for safety.

This was a fatal step, because Lyon overthrew its revolutionary government and was reconquered by the army of the Convention. Father Ampère, who had been chosen as judge of the peace, was arrested on the trumped-up charge of being an aristocrat and perished on the scaffold. André-Marie was then 18 years old, and the blow all but shattered him. For two years after his father's death he was sunk in apathy and incapable of thought or action.

André-Marie Ampère

This is a portion of the portrait by E. Maxence that hangs in the Lecture Theatre at Savoy Place

Before this disaster overtook the family, young Ampère had already shown some of his superb intellectual powers. He did not attend school, but learned from books which his father brought home for him. At the age of 11 someone had given him a few lessons on the differential calculus, and at 13 he read the works of Euler and Bernoulli. Since these were in Latin he had to teach himself to read that language.

Marriage

Slowly time did its healing work on Ampère. He was once again able to enjoy walking in the woods and collecting plants. He began to derive comfort from Latin poetry. And then he met Julie. There was no chance to speak to her, and he did not even know her name; all he knew was that he was madly in love. He found out that she lived in a village nearby, and next day he went to see her parents to ask for Julie's hand in marriage.

Her parents were not impressed by Ampère; nor was Julie, who had recently rejected another suitor. Ampère was turned away. But love is strong and persistent, and three years of courtship gained their reward: André and Julie were married in August 1799. Ampère's diary and correspondence in the intervening years show such a story of true and unaffected love that they are a classic in their own right.

Then tragedy

With marriage come responsibilities. Julie's parents thought Ampère ought to work for his living and suggested that he become a shop assistant. In the end he decided to give private lessons at Lyon, but the income was not sufficient. Pupils came and went, and when the offer of a teaching post at Bourg came he accepted, although it meant leaving Julie and his baby son behind.

At Bourg, Ampère wrote his first important paper and there he also did much experimental work in chemistry. If it had not been for his separation from Julie, his happiness would have been complete. But for the second time stark tragedy entered his life. Julie was not well. She wrote brave letters, but they had been composed with evident difficulty; then she died. For the second time Ampère's life was in ruins.

Just before his wife's death Ampère had been offered the very promising post of teacher of mathematics and astronomy at the Lycée at Lyon. But the memories of past happiness made Lyon impossible, and he obtained the position of reader in mathematical analysis at the École Polytechnique in Paris. Slowly he rebuilt his life and turned for help to metaphysical discussions; but the wound caused by Julie's death never healed and happiness was no longer possible.

A second marriage proved a disaster, his wife leaving him soon after the birth of their daughter. Happily, Ampère's sister came to run the household for her brother and the two children.

An eccentric professor

From a scientific point of view this was a very creative period of Ampère's life, and in 1814 he was elected to the Academy of Sciences. The supreme honour came ten years later when he was appointed Professor of Experimental Physics at the Collège de France. He was surrounded by brilliant men: Laplace, Fourier, Fresnel, Poisson and Cuvier were only a few among the many names that showed Paris to be the scientific capital of the world of that time. Among them Ampère was acknowledged as one of the greatest.

Not that everyone approved of Ampère. His students did not care for his style of lecturing and they had some reason for their objections, since the lecturer was terribly absent-minded and was continually going off at a tangent. They pulled his leg mercilessly and told him that they could not read his writings on the blackboard. Poor Ampère made his letters larger and larger until he could get only a few words on the board at any one time. They laughed at him when, in the heat of exposition, he mistook the blackboard duster for his handkerchief and wiped his face with it.

The students were not the only people who disapproved of Ampère. The trouble was that he was incapable of pretending to enjoy a dull lecture or social gathering. He would start to fidget and to walk about until 'boredom oozed from every pore of him', and if invited to dinner he would plainly show it if the meal were not to his liking. He was completely truthful and had never learnt to hide his feelings.

In scientific circles many disapproved of the way in which he switched from subject to subject. He would be tremendously enthusiastic for a while and then lose interest. It was all very regrettable, but he was undisciplined, tactless, credulous and unscientific, said the critics. They were right, but they forgot that Ampère was no ordinary career-scientist but a genius.

A few people, among them those whose opinions were most valuable, realized the true worth of Ampère as well as his weaknesses. Sainte-Beuve, in a very discerning essay, wrote of his friend that he was the supreme example of the scientific adventurer pushing on under the impulse of a tremendous desire to know. That was why in 1820 Ampère had been able to drop all other interests and concentrate his powerful intellect on Oersted's experiment and all its consequences. Electrical engineers have every reason to be grateful that Ampère was such an adventurer.

A follower of Newton

Ampère incorporated his electrical researches into one long paper published in 1825. At the outset of the paper he declared himself to be a follower of Newton. Just as gravitation could be explained by the action between particles of mass, so he sought to explain the effects of currents by the action between current-elements, and he did not see the necessity for attributing this action to magnetic fields. His theory was based on four beautifully designed experiments, which made use of the null method of measurement.

These experiments showed that:

1. The effect of a current was reversed when the direction of the current was reversed
2. The effect of a current flowing in a circuit twisted into small sinuosities was the same as if the circuit had been smoothed out
3. The force exerted by a closed circuit on an element of another circuit was at right-angles to the latter
4. The force between two elements of circuit was unaffected when all linear dimensions were increased proportionately, the current strengths remaining unaltered.

For the purpose of his experiments, Ampère invented the galvanometer and an astatic current-balance.

Besides the information deduced from these four experiments, Ampère made use of two hypotheses, namely that action and reaction between two current-elements were equal and opposite and that the force between them acted along the line joining the elements. This led him to his famous formula, which received such praise from Maxwell. The force between two current-elements is:

$$F = \frac{1}{2}\frac{ii'\mathrm{d}s\mathrm{d}s'}{r^2}\left(2\cos\varepsilon + 3\frac{\mathrm{d}r}{\mathrm{d}s}\frac{\mathrm{d}r}{\mathrm{d}s'}\right)$$

where ε is the angle and r is the distance between the elements $\mathrm{d}s$ and $\mathrm{d}s'$.

In vector notation this becomes:

$$F = \frac{1}{2} ii' r \left[\frac{2}{r^3} (\mathbf{ds}.\ \mathbf{ds}') - \frac{3}{r^5} (\mathbf{ds}.\ \mathbf{r})\ (\mathbf{ds}'.\ \mathbf{r}) \right]$$

Some weaknesses

This formula will be unfamiliar to many engineers, and this unfamiliarity underlines a weakness in Ampère's work. The weakness lay in Ampère's two hypotheses. Even if action and reaction were equal and opposite, there was no need for the force to act along the line joining the elements. There might be a force in another direction and a couple, as in the action between two magnetic dipoles.

Ampère met this objection by saying that magnets were more complicated in structure than current-elements and that the forces between them were therefore more complicated. Although he realized that electric current was a kinetic phenomenon (indeed, he invented the word 'electrodynamics'), he thought of current-elements as particles and tried to find the simplest law of force between these particles.

He did not realize that physically his isolated current-elements were an impossibility and would have to be immersed in a conducting ocean in order for the current to flow at all. This was pointed out later by Oliver Heaviside, who proposed a 'rational' current-element immersed in such a fluid. Since there would be currents within the fluid as well as in the elements, there was no reason to expect that action and reaction between Ampère's isolated current-elements would necessarily be equal.

In fairness to Ampère, it must be stated that he knew that his hypotheses were not necessary, and that many different formulae would give the same answer when integrated around a closed circuit. But he thought that his formula was the most convenient one, and in this he was mistaken.

The founders of electrical engineering

However, the importance of Ampère's work does not lie only or chiefly in his formula. It lies rather in the careful experimental and mathematical investigation which enabled him to state the exact relation between magnets and steady electric currents. Thus he established that a magnetic dipole was in all respects equivalent to a small current-loop and that a current circuit of arbitrary shape could be replaced by a magnetic shell having that circuit for its boundary.

His profound knowledge of mechanics guided him in investigating in what circumstances continuous motion was possible in a system of magnets and currents, and he arrived at the correct conclusion that such continuous motion was impossible with magnets and circuits of fixed configuration but that it was possible if a part of a current circuit were allowed to move.

In reading the great *mémoire* of 1825 one knows at once that it is the work of a man who was master of every aspect of his subject and that here are the foundations of the electrical age in which we live. Ampère and Faraday were truly the founders of the profession of electrical engineering.

The waning years

His great work accomplished, Ampère began to lose interest in electrical matters. This was due partly to his strange genius and partly to outside circumstances. He had been appointed inspector of colleges and had to travel throughout France to examine the accounts of the various institutions. A worse appointment for an absent-minded, tactless professor would be hard to imagine.

When he had time, he devoted his remaining years to a fantastic scheme which only Ampère would have thought possible. He proposed to write an encyclopedia in which all the sciences were to be shown in their relations to one another. If such a work could have been accomplished by anybody, Ampère would have been the best man for the task, but the thing was manifestly impossible. Perhaps if Julie had been alive she would have laughed him out of making the attempt; as it was he toiled on, knowing he was getting nowhere.

The end

His health began to fail, and the end came in 1836 while he was at Marseilles on one of his tours of inspection. A friend tried to give comfort by reading to him passages from Thomas à Kempis's 'Imitation of Christ', but he had not reckoned with Ampère. In a weak voice, the dying man said 'Thank you, but I know the book by heart'.

For his epitaph, Ampère chose the words *Tandem felix*: 'Happy at last'. His had not been an easy life, but his faith assured him that a better one was yet to come.

WEST RIDING POWER-STATION SITES

Two sites have been found suitable for large coal-fired power stations in the West Riding of Yorkshire, the Central Electricity Generating Board recently announced. One of these is an extension of the Board's existing site at Ferrybridge near Castleford; the other is at Eggborough, about four miles east of Knottingley.

Both are on the eastern fringe of the Yorkshire coalfield, which possesses large reserves and is expected in future to supply increased quantities of the small coal burnt in power stations. The Ferrybridge site already has a rail connection, and, being located on the navigable part of the River Aire, it can also receive coal sent by barge from those collieries accessible to water transport. Rail facilities for the Eggborough site can be realized by connecting to a short spur off the Wakefield–Knottingley–Goole railway.

The two sites are considered suitable for stations of about 2000MW capacity each, burning five million tons of coal a year. Early construction of the stations is necessary to meet the rapidly increasing electricity demand, and the Board are applying to the Minister of Power and the West Riding County Council for the necessary consents.

Protection of transmission and distribution lines containing series capacitors

621.316.925 : 621.315.1.054.42

Series capacitors are playing a growing part in the design of transmission and distribution systems. One limitation of their use is the adverse effect of high degrees of compensation on the operation of the line-protection equipment.

This article describes how this effect can be mitigated by the use of power-factor-sensitive elements in the relay circuits. The author is with the Southern Rhodesia Electricity Supply Commission.

J. L. HAMLIN, ASSOCIATE MEMBER

WHILE an unloaded overhead transmission or distribution line is capacitive in character, fully loaded lines inherently possess resistive and inductive properties. The inductive reactance of the line contributes to the voltage drop and, in cases where the load power factor is low and lines are of large cross-section, it becomes the major component of the voltage drop.

Permissible voltage drop is the factor that usually limits the power that may be transmitted by means of distribution and secondary transmission lines.

With e.h.v. lines interconnecting centres of generation, the power that may be handled is again limited by the inductive properties of the line. Because such lines operate at, or very near to, unity power factor, voltage drop is usually not an important matter. In such cases, it is the stability limit of the system that determines the amount of power that may be transferred, and this tends to be inversely proportional to the inductive reactance of the line.

Capacitors in series with loaded transmission or distribution lines act in direct opposition to the inherent inductance of the lines. They permit a considerable increase in the power that may be transmitted in lines—ranging from rural feeders at one end of the scale to e.h.v. interconnectors carrying major blocks of power at the other. Alternatively, they may be used in distribution and secondary transmission lines to improve voltage regulation for a given power transfer. This they do automatically and in a time which, for practical purposes, can be regarded as instantaneous.

They may also be used in e.h.v. interconnectors to equalize load sharing between parallel lines of different cross-section, spacing and/or length.

The degree to which the capacitive reactance compensates line inductive reactance varies between wide limits depending on the type of application. With high-power interconnectors the compensation is not likely to exceed 50% of the line reactance; but with distribution lines of small cross-section it may be 300% or more. This arises because, with this type of line, voltage drop due to resistance is a large proportion of the total, and 100% compensation of the inductive component of voltage drop does not yield worthwhile results.

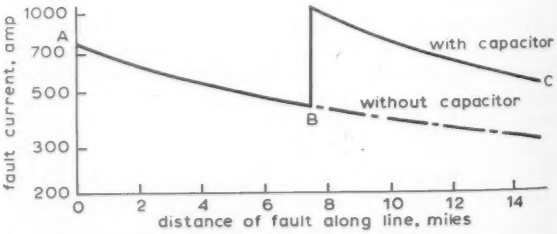
Fault current with series capacitor

When a fault occurs on a line containing a series capacitor, the current passing through and, consequently, the voltage developed across the series capacitor rise sharply. In order to protect the capacitor, some means of removing it from the circuit must be employed. This usually takes the form of an arc-gap which may or may not actuate other equipment, such as contactors, shunting the capacitors.

The inclusion of capacitors in series with a line alters the nature and value of its impedance, and this can have a marked effect on the current flowing in fault conditions. For instance, for a line without series capacitors, the current flowing in line faults of negligible impedance becomes progressively less as the distance from the source to the fault increases, but with series capacitors in the line the fault current jumps to a relatively high level for faults occurring immediately on the load side of a capacitor. This is caused by the comparatively large decrease in the inductive reactance of the fault path brought about by the capacitor.

Fig. 1 shows the current flowing in a solid phase-to-phase fault on a typical 11kV 0·075in.² rural line with a 10Ω series capacitor installed at the mid-point. The large rise in fault current beyond the capacitor is clearly shown.

It follows that the performance of the normal type of equipment protecting the line is influenced by the presence or otherwise of the capacitor. With threshold faults, the arc-gap shunting the capacitor may or may not have operated, and the performance of line-protective equipment will fail to be consistent.



1 *Fault current for phase fault on a typical distribution line with series capacitor*

10Ω series capacitor installed at mid-point of line B

Rural-line protection

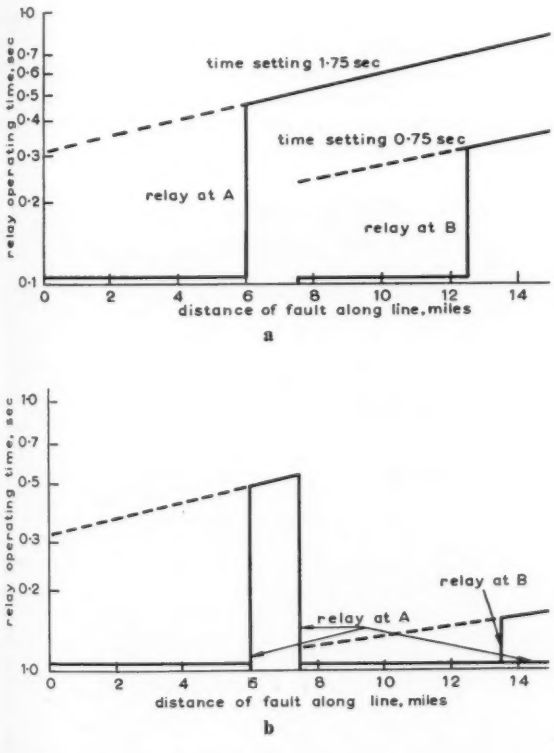
Types of equipment used to protect lines fall into fairly well defined groups. Lines of rural- and secondary-transmission type are normally protected by inverse-with-definite-minimum-time-lag (i.d.m.t.l.) overcurrent and earth-fault relays. If the line is in two or more sections, the relays nearest the source are set to operate in the longest time and those most remote in the shortest time. Grading is thereby achieved, and faults on the remote section cause only that section to be isolated. The usual time discrimination between relays protecting successive sections of line is about 0·4sec.

Where a line has a number of sections, the relay nearest the source has an excessively long minimum operating time. This disadvantage may be overcome in some cases by using relays with very inverse current/time characteristics, whereby the time discrimination between succeeding relays may be reduced.

A further refinement occurs with i.d.m.t.l. relays fitted with instantaneous elements. The latter are attracted-armature elements whose current settings are adjusted so that they operate with faults occurring within the first 80% of the line section protected by the relay. Thus there is instantaneous operation of the nearest relay for faults occurring in the first 80% of any section of line, as shown in Fig. 2a.

The presence of a series capacitor precludes the use of instantaneous elements on relays preceding the capacitor, because for faults on the load side of the capacitor the current, as may be seen from Fig. 1, approaches or even exceeds that occurring at the beginning of the line. The result is that the instantaneous elements at A again become operative for faults on the load side of the capacitor, as shown in Fig. 2b; and because of this the protection at A and B does not discriminate.

With normal and very inverse overcurrent protection, the time/current rating of relays preceding the capacitor has to be increased. Besides making the operating time of near-end relays very long, it may impair grading with relays nearer to the power station.



2 *Relay times using very inverse relays with instantaneous elements*

a Line without capacitors b Line with capacitors

Transmission-line protection

For transmission lines, three types of protection have been commonly used. These are suppressor-coil, distance and carrier-current protection. The first mentioned is now somewhat outmoded; distance protection is widely used, particularly in oversea territories.

Although distance-protection relays may be sub-divided into definite-distance, time-distance, and high-speed stepped time-distance types, the underlying principle is the same. The relay measures voltage and current, the quotient of which is the impedance of the circuit. If a fault occurs near a relay, the fault impedance as seen by that relay is small. The smaller the impedance seen by a relay, the shorter will be its operating time, and so the only relay to operate will be the one controlling the section in which the fault occurs.

A series capacitor will completely distort the impedance of a fault occurring on its load side. With high degrees of compensation, it can even make the relay controlling the section preceding that containing the capacitor 'see' the fault as occurring on its supply side. Thus series capacitors preclude the use of distance protection unless the reactance of a capacitor situated at the middle of a line section is less than half that of the section.* The section itself may comprise a half, a third, a quarter or less of the total line length, and so the degree of series-capacitor compensation that can be used on multi-section lines with distance protection is reduced to a level where its benefits are not worth while.

A method of overcoming this difficulty is to employ a series capacitor in each line section. This is expensive because the cost of capacitor protective equipment tends to remain constant in spite of the reduced size of each capacitor bank.

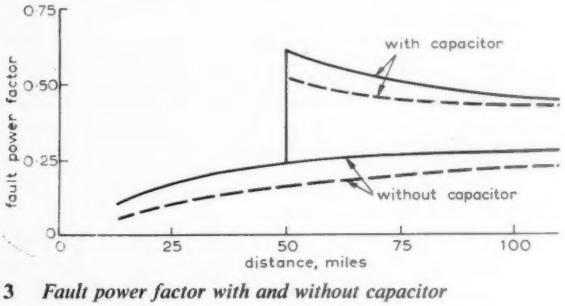
We are thus faced with a position in which a practical and economic series capacitor that can be used in a multi-section line normally employing distance protection has a reactance much exceeding that of half a line section. This precludes the use of distance protection

* YERMOLENKO, V. M., and PETROV, S. J.: 'The effect of series-capacitor compensation on relay operation', C.I.G.R.E., 1956, Paper no. 323

unless some means of discriminating between supply-side and load-side faults is introduced.

'Seeing' the fault position

A significant difference between faults on the supply side and on the load side of the capacitor is that the power factor presented by load-side faults is much higher than for source-side faults if a series capacitor is present. This is shown in Fig. 3.



3 *Fault power factor with and without capacitor*
——— Earth faults - - - - Phase faults

By incorporating a device sensitive to power factor in the distance relays protecting the line section or sections preceding that containing the series capacitor, it is possible to prevent them from 'seeing' faults on the load side of the capacitor. Such faults have a relatively high power factor, and the trip circuits of circuit-breakers controlling those sections are prevented from operating by action of the power-factor-sensitive element.

The distance relay at the beginning of the section containing the series capacitor must operate for faults of both low and high power factor, depending on the position of the fault in that section. This can be achieved by making the power-factor-sensitive element control the reactance-measuring element in the distance relay. Thus, when the capacitor is in circuit, an equivalent reactance is included in the measuring circuit. Relays in sections on the load side of the capacitor section are of standard type.

Power-factor-sensitive relay

With lines of the type normally protected by distance relays, the operating time of the power-factor-sensitive element must be short.

For lines of a type normally protected by i.d.m.t.l. protection, such fast determination of fault power factor is not essential, and relays of the normal induction type can be used for the power-factor-sensitive element. This element enables the ordinary protective relays to 'see' whether or not the capacitor is in circuit for faults on its load side.

Summary

Excluding cases where instantaneous elements are used, the performance of protection equipment on rural distribution lines is not adversely effected by the presence of series capacitors.

With distance protection in a line section having a high degree of compensation, it becomes necessary to use a device of the type outlined in this article in order to obtain satisfactory performance.

MOBILE CONTROL ROOMS FOR B.B.C.

Five mobile control rooms for television outside broadcasts are to be built for the British Broadcasting Corporation. Each one will be equipped with four 4½ in. image-orthicon camera channels and will be capable of operation with up to 2000 ft of camera cable. It is expected that the first of these mobile control rooms will be delivered in 1962.

Four of the mobile control rooms are for use in the B.B.C.'s Welsh, Scottish, West of England, and Midland Regions, where they will replace existing three-camera mobile control rooms. The fifth will be used to augment the B.B.C.'s outside-broadcast facilities in the London area.

Power consumption and heat dissipation from the equipment will be minimized by the use of transistors instead of valves wherever possible, notably in the sound equipment, pulse generators, intercommunication, and vision mixer.

The vision-mixer control panel will be a detachable unit that can be operated, when required, up to 300 ft from the main equipment. The vision mixer will accept up to ten sources, four of which may be asynchronous; the sound mixer will accept up to 20 sources. Production facilities will permit parts of two pictures to be transmitted simultaneously.

The mobile control rooms will be capable of operating on the European 625 line or the American 525 line standard as well as on the 405 line one.

GATHERING INFORMATION

The major purpose of the new Vera (versatile experimental reactor assembly) at the Atomic Weapons Research Establishment, Aldermaston, which went critical in February 1961, is to gather information on medium-enriched, diluted, and slightly moderated fast-reactor systems.

The control room, fuel-element assembly room, laboratories, plant room for the ventilation system and filters, and a laboratory to house a 600 kV accelerator still under construction, are located round the reactor cell. The accelerator will be used to produce deuteron beams aimed at targets in sub-critical Vera cores, which will yield bursts of neutrons in a series of kinetic experiments, with varying core compositions, to measure reactivity increments and neutron lifetimes and to study neutron spectra.

Each fuel element consists of two stainless-steel U-channels into which ⅛ in. thick, roughly square 'biscuits' of enriched uranium, natural uranium and graphite are stacked in numbers and patterns that can be selected to correspond to practically any fuel dilution or degree of moderation. Only the central portion of each element is occupied by this mixture, the remainder of the stack consisting of thicker blocks of natural uranium or other materials serving as the reflector.

Closed-circuit television is used to watch operations from the control room.

Instrumentation and control of nuclear reactors

SCOTTISH CENTRE ELECTRONICS AND MEASUREMENT GROUP SYMPOSIUM

THE newly formed Electronics and Measurement Group of the Scottish Centre recently organized a two-day symposium on the instrumentation and control of nuclear reactors, several of the papers in which referred particularly to the fast reactor and to the materials-testing reactor at Dounreay. Over 120 participants assembled for Saturday and Sunday, 25th and 26th March 1961, at the Chesters residential centre of the Royal College of Science and Technology at Bearsden near Glasgow; ten papers were presented, and extensive discussions ensued.

At the opening session, Mr. J. Stewart, Chairman of the Scottish Electronics and Measurement Group, welcomed the participants, and Mr. C. G. Garton, Chairman of the Measurement and Control Section, brought best wishes for the success of the symposium. The first paper, by Mr. R. C. Wheeler, 'An introduction to the control of nuclear reactors', reviewed the general problem of control, the neutron cycles for fast and thermal reactors, and the terminology at present in use, thus providing a secure foundation on which the succeeding specialist lecturers could build.

The fast reactor

Mr. J. Allen dealt with 'Operational experience on the Dounreay fast reactor'. He described the commissioning problems and the first phase of reactor operation. The reactor was handed over in December 1958, and the first part of the commissioning programme comprised comprehensive tests on all the flasks used to transfer components into and out of the primary liquid-metal circuit, the essential feature being the complete avoidance of air coming into contact with the liquid metal. Testing 'in air' showed a number of mechanical defects, which were corrected before the final tests on sodium were carried out.

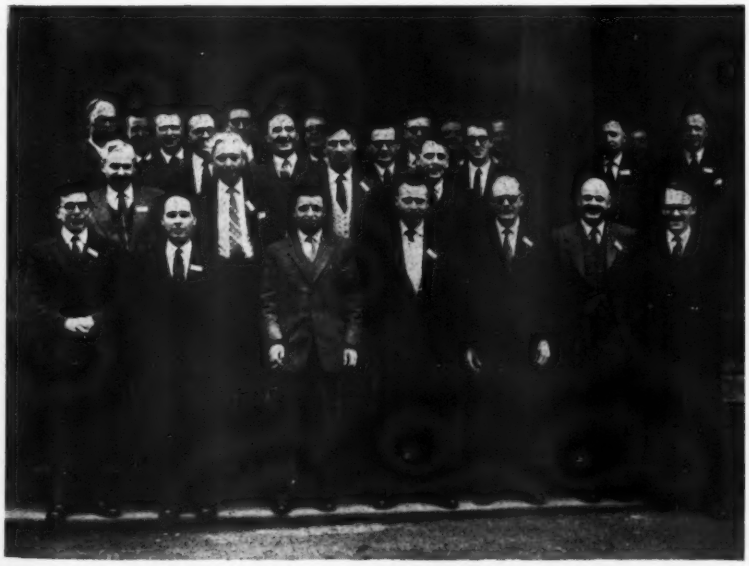
Mixing the 119 tons of liquid sodium–potassium alloy to obtain the desired 72 : 28 proportion gave much trouble owing to the formation of solid residues, although once this was overcome the transfer to the reactor took place with no great difficulty. Charging the reactor and replacing certain of the elements with enriched elements to achieve criticality were successfully completed by November 1959. A major operational problem was the removal of oxide from the liquid metal, mainly by 'cold trapping', and the measurement of the amount of oxide removed. Zero-energy physics experiments were carried out and showed no major variations from the predicted behaviour.

In April 1960 the reactor was shut down, in accordance with plan, to change the core, and the opportunity was taken to make modifications to the control rods and to install additional instrumentation to investigate entrainment of nitrogen in the liquid metal. The nitrogen had been suspected of causing certain observed power fluctuations. The new core had now been installed, and further zero-energy experiments had been carried out.

Instrumentation

The 'Instrumentation of the Dounreay fast reactor' was discussed by Mr. R. Smart. The equipment was basically similar to that of thermal reactors of the Calder Hall type. Special problems arose, owing to the immersion of measuring devices in liquid metal, to the fuel-element cans being vented to the coolant so that both liquid metal and the gas blanket became highly radioactive, and to the fact that the coolant, if allowed to leak from the system, presented a serious fire risk so that sealing arrangements where cables passed through a container had to be of exceptional integrity. Furthermore, reactor-core instrumentation was difficult owing to the small core size and because of the rotating shields used over the core for charging.

Special problems arose with liquid-metal measurements, and instruments not requiring physical contact with the metal were used where possible. Flow rates were determined by measuring the e.m.f. between two electrodes placed on each side of the pipe, this e.m.f. being induced in the metal as a result of a permanent magnet external to the pipe. Measurement of level was effected by a long mutual-inductance probe in a stainless-steel tube projecting into the metal, the metal acting as a short-circuited turn which reduced the inductance in



Mr. J. Stewart, Chairman of the Scottish Electronics and Measurement Group (second from left, front row), and some of the participants in the symposium on instrumentation and control of nuclear reactors

proportion to the length immersed. Pressures were measured by special Bourdon and capsule gauges, and temperatures by thermocouples with stainless-steel sheaths.

Attempts to measure oxide concentration were made by detecting small variations in conductivity and by a blocking orifice which measured the restricted flow due to the presence of oxides. Stability was studied by a rotatable D-shaped absorber lowered into the core which, when rotated, produced a sinusoidal variation of reactivity between 0·002 and 3c/s. The modulation of the neutron flux was observed by a transfer-function analyser.

The Dounreay materials-testing reactor (D.M.T.R.)

The operation of a research reactor, with particular reference to the operator's viewpoint, was described by Mr. W. H. Lunning in a paper 'Operational experience and requirements for instrumentation in D.M.T.R.'. The D.M.T.R., the first reactor to be made critical in Scotland (May 1958), was of the heavy-water type and generally similar to Dido and Pluto at Harwell. Instrumentation and safety devices had to be provided not only for the reactor but also for as many as 25 test rigs. Each rig had to be fully equipped with safety devices of as high a standard as those for the reactor itself, with instruments, cooling circuits, and miscellaneous services as required by the experimental physicists and engineers.

The main problem was therefore finding 'out-of-pile' space for all this equipment within the containment building, remembering that the equipment was continually being changed; the operating routine was on a four-week cycle, one week of which was a shut-down period for changing rigs.

As a corollary to the above paper, Mr. A. L. Whitwell discussed various instruments designed to occupy a minimum of space and tending towards standardization in size; these included magnetic-tape storage that recorded information from 15 sec before to 5 sec after a reactor trip, digital instruments and print-out recorders. Even with improved instrumentation, it was concluded that the proper solution would be to have a single control room for both reactor and experimental rigs outside the containment building and a rig-data room where all rig information could be presented.

The control equipment for heavy-water reactors such as the D.M.T.R. was described in the paper 'A thermal-reactor control system' by Mr. F. Roberts. The shut-down and coarse-control devices were of the signal-arm type, operating between the fuel elements and being 'fully out' when horizontal and giving maximum absorption when at 56° to the horizontal; the drive was by electric motors through slave gearboxes operated from a master gearbox. Fine regulation was by a screw-operated absorber rod, and the safety elements were also absorber rods wound out of the core through a gearbox incorporating a magnetic clutch that could be de-energized to allow the rods to fall under gravity in the case of a reactor trip.

Although the equipment seemed somewhat complicated, it could be comprehensively tested before installation in the reactor, so that commissioning troubles were reduced to a minimum.

Measurement and control techniques

In presenting a paper 'The development of improved nuclear measuring techniques', Dr. D. Taylor explained new trends in instrument design. Ionization and fission chambers were capable of greater stability and accuracy than other types at the high temperatures now being envisaged (up to 500°C) and had to function at neutron fluxes of at least 10^{13} n/cm^2/sec; instruments relying on the fission reaction in uranium 235 had an acceptable life in these conditions, a recent design having five times the sensitivity of models at present employed.

Solid-state detectors were showing spectacular improvements, silicon junction diodes being used as particle detectors and, together with cadmium sulphide and gallium arsenide diodes, as γ-ray detectors.

Motors for control-rod operation generally require an l.f. supply (0–1·0c/s), and Mr. J. A. Purdie in his paper 'The application of magnetic amplifiers to reactor control' described a method of generating such currents that was to be used for the thermal reactors at the Trawsfynydd nuclear power station of the Central Electricity Generating Board. A small l.f. 3-phase signal was generated by magslip transmitters and phase-sensitive detectors and was fed to magnetic amplifiers, the output from which supplied the rod motors; the major part of the equipment was thus static, and the life of the magnetic amplifiers and the associated silicon rectifiers should exceed 20 years.

With any nuclear project there must be a comprehensive monitoring service for the personnel, and Dr. D. H. Pringle presented 'Human-body radiation monitors', in which he discussed the use of scintillation counters for the detection of potassium 40, medical research with radioactive tracers, monitoring of nuclear personnel, and detection of fall-out from nuclear explosions. The activities to be observed were usually one or two orders of magnitude less than the background activity due to natural surroundings, so the subject and detection equipment had to be surrounded by an absorbing non-radioactive screen.

Large plastic or sodium iodide scintillators viewed by photomultipliers gave satisfactory results, although there were still difficulties with calibration. A typical unit comprised two sodium iodide crystals above the patient and two below, each crystal being 5 in. in diameter × 4 in. deep and viewed by 5 in. photomultipliers. The whole was in a room with 6 in. steel walls lined with lead $\frac{1}{4}$ in. thick; the outputs were fed to an electronic unit which printed out the various desired counts.

Associated with the above papers was an excellent and extremely lucid presentation by Mr. D. C. G. Smith of a somewhat mathematical paper 'Kinetic behaviour of fast reactors'.

The human element

Although all the papers gave rise to lengthy discussions, the most controversial was the last paper 'The human factor in control-room design', in which Mr. H. D. Howse outlined a study of the subject carried out by a team of American consultants. A control-room operator and his control room had to be treated as a man–machine system forming part of a larger system, the power station, which was itself part of a still larger system, the national Grid. The designer had to decide what functions had to be performed and allocate them between men and machines, paying particular attention to the 'man–machine interface'.

In deciding the role of man, three factors required special attention—boredom, which was a major problem for control-room staff; flexibility, so that as the operators gained insight into the functioning of the system they could make its performance more efficient; and safety, which required initial training and continuous practice on a simulator since dangerous situations occurred so rarely. Man's primary functions

were thus making decisions in abnormal circumstances and managing the system to secure maximum safety and efficiency; man should never be used as a primary safety device, as a continuous controller or as a monitor.

It was recommended that there should at all times be three men on duty in a control room: first, an 'officer', who should actively control the reactor and all associated plant, who should be a high-calibre man professionally trained in physics and engineering, and who at intervals should act as supervisor in the reactor building and in the turbine hall; secondly, a 'sergeant', who should be a technician capable of carrying out established operating procedure; and thirdly, a 'private', who should make the tea and carry out minor routine duties.

The actual design of the control room should be such that the man was obviously in charge, e.g. possibly by seating him in an elevated position, and certainly not overshadowed by towering banks of instruments. Only essential information for moment-to-moment control should be presented, any instruments giving information for record purposes being installed elsewhere, the record preferably being made on punched cards or magnetic tape. Deviation instruments and on-demand information were particularly valuable. It was finally pointed out that a reactor shut-down might cost £10000, so that time and money spent on human engineering was justified if it could prevent even one shut-down per year.

Conclusion

In summing up the symposium, Mr. L. Tweedale of Dounreay, who was one of the chief organizers, referred to the original purpose, which had been to enable engineers from various organizations to exchange experiences in the operation of nuclear reactors; this purpose had been admirably achieved, not only in the formal sessions but also in the many informal discussions that had resulted from the fact that it had been a *residential* symposium. The hope was expressed, and warmly applauded, that a similar symposium should be held in the future when some of the equipment referred to and now being installed had been put to operational use.

E. OPENSHAW TAYLOR

Centennial Convocation of the Massachusetts Institute of Technology

SIR Willis Jackson, D.SC., D.ENG., LL.D., F.R.S., IMMEDIATE PAST-PRESIDENT, recently paid a visit to Canada and the United States arising from an invitation to participate in the Centennial Convocation, from the 3rd to 9th April 1961, of the Massachusetts Institute of Technology at Cambridge, Boston, Massachusetts, and in the international conference on scientific and engineering education which comprised the initial phase of the Convocation.

Sir Willis was a personal delegate, but agreed to attend also as a representative of British engineering, jointly nominated by The Institution and The Institutions of Civil, Mechanical and Chemical Engineers.

International character of the conference

The international conference occupied the first four days of the Centennial week and was attended by about 100 invited scientists and engineers drawn from various universities and colleges in the United States, including the M.I.T. itself, and from 30 other countries. The participants were divided into four groups for discussion of the following themes, on each of which a few background papers had been written and circulated beforehand.

The theme of Group 1 was 'The problems of scientific and engineering education in newly developing countries'. The British participants in this group were Profs. P. M. S. Blackett and A. Salam of the Imperial College of Science and Technology, London. Group 2 was concerned with 'The problems of scientific and engineering education in countries with more advanced technologies', in which the British participants were Sir John Cockcroft, Prof. J. F. Baker of Cambridge University, Prof. R. Peierls of Birmingham University and Sir Willis Jackson. Sir Willis prepared one of the background papers.

Group 3 discussed 'Interactions of science, engineering and society', for which Sir Eric Ashby of Cambridge University prepared a background paper. The subject for Group 4 was 'Implications of science and engineering for international relations', in which the United Kingdom was represented by Mr. Nigel Calder, the scientific journalist, the Rt. Hon. Philip Noel-Baker, M.P., and Sir Solly Zuckerman, Chairman of the Defence Research Policy Committee.

Summaries of these discussions, together with the background papers, are to be published in a series of books in due course.

Atoms for Peace Award

The concluding event of the international conference, and one which gave much satisfaction to the British participants, was the presentation to Sir John Cockcroft of the 1961 Atoms for Peace Award of $75000 and a gold medallion. This satisfaction was greatly enhanced on the following day, Friday, 7th April, by the evening address of the British Prime Minister, the Rt. Hon. Harold Macmillan, to an immediate audience of over 3500 supplemented by at least an equal number accommodated, and provided with television display, in several enormous marquees.

The Saturday was devoted to a series of short lectures, given simultaneously in a number of auditoria, on the subjects: how has science in the last century changed man's view of himself?; the future of the arts in a world of science; the future of the physical sciences; arms control; the life of man in industry; and the future of the life sciences. Among the speakers from Britain were Mr. Aldous Huxley, Sir John Cockcroft, Prof. Peierls, the Rt. Hon. Philip Noel-Baker and Prof. P. B. Medawar.

End of the Convocation

The Centennial Convocation concluded on Sunday, 9th April, with an academic procession, with expressions of congratulation and of greetings from selected members and from old students, and finally with an address by the President of the Institute, Dr. Julius A. Stratton (1961 Faraday Medallist of The Institution), in which he reviewed with justifiable pride the past achievements of the M.I.T. and sketched the problems and the responsibilities that lie ahead of it.

A nuclear-thermionic convertor

621.385 : 621.039

In April 1960 in the United States, a nuclear-heated thermionic diode, consisting of a uranium carbide cathode and copper anode, produced 90 W of electricity at efficiencies and power densities adequate for practical applications. In this article the author gives a short account of this thermionic cell, which he considers gave very promising results.

Mr. Howard is at the John Jay Hopkins Laboratory for Pure and Applied Science, General Atomic Division of General Dynamics Corporation.

R. C. HOWARD

For about the past two years, there has been a rapidly growing interest in the direct conversion of heat to electricity by the use of thermionic cells. It has been found that inclusion of caesium vapour between an incandescent cathode and a cooler anode eliminates space-charge effects and permits useful power to be drawn from a thermionic diode. It has further been found that uranium carbide, already being developed as a fuel material for nuclear reactors, is a copious emitter of electrons. Therefore, the simultaneous use of uranium carbide as both the cathode of a thermionic cell and the fuel material for a nuclear reactor appears quite attractive.

This combination, referred to as a nuclear-thermionic power system, would have potential uses as a space, marine or power-station plant. To investigate the possibilities of such a system, an in-reactor test was conducted of a caesium-vapour diode utilizing uranium carbide as both the cathode and the heat source. This test simulated the conditions that would be experienced by one element of a nuclear-thermionic reactor system.

Description of experiment

A schematic of the in-pile part of the experiment is shown in Fig. 1. The emitter, composed of 95% (by weight) uranium carbide (the uranium was 93% uranium 235) and 5% zirconium carbide, and of 0·50 in. diameter × 0·50 in. length, was supported by a stem, of the same composition but with natural uranium replacing the enriched uranium, of 0·20 in. diameter × 0·50 in. length. This stem, which was also the electrical connection to the emitter, passed through an insulator in the copper collector (anode) that surrounded the cathode.

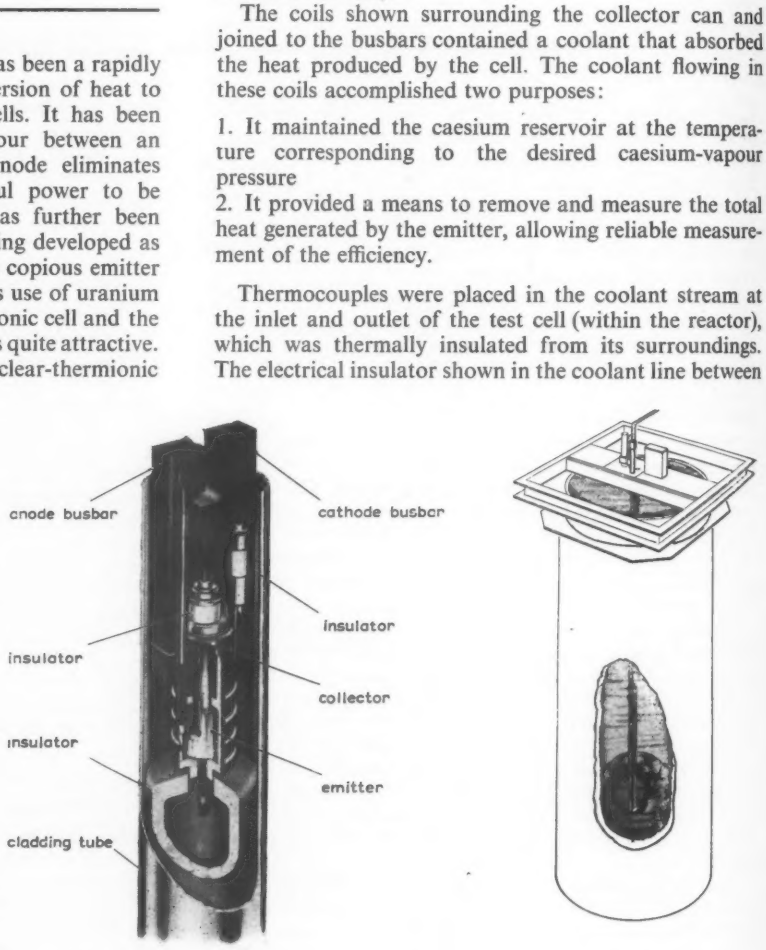
Between the can and the emitter was a gap of about 0·040 in., which was permeated by caesium vapour from the liquid-caesium reservoir.

Because of the large currents produced by the cell and the great distance from the reactor core to the electrical load and measuring instrumentation, thick copper busbars were required to minimize lead losses. These bars are shown in Fig. 1 as the cathode busbar (connected to the emitter stem) and the anode busbar (connected to the collector can).

The coils shown surrounding the collector can and joined to the busbars contained a coolant that absorbed the heat produced by the cell. The coolant flowing in these coils accomplished two purposes:

1. It maintained the caesium reservoir at the temperature corresponding to the desired caesium-vapour pressure
2. It provided a means to remove and measure the total heat generated by the emitter, allowing reliable measurement of the efficiency.

Thermocouples were placed in the coolant stream at the inlet and outlet of the test cell (within the reactor), which was thermally insulated from its surroundings. The electrical insulator shown in the coolant line between



1 *In-pile test assembly*

the cathode busbar and the collector was required to prevent the electrical short-circuit that would have occurred from the coolant line, which was common to the cathode busbar and the collector.

The entire assembly was housed in an aluminum cladding tube that normally housed a reactor fuel element. A larger aluminum tube joined to the cladding tube above the core level housed the coolant lines, busbars and thermocouple leads. When assembled, the cladding tube was inserted into a regular fuel-element position in the reactor, with the larger-diameter tube extending above the surface of the water of the reactor pit.

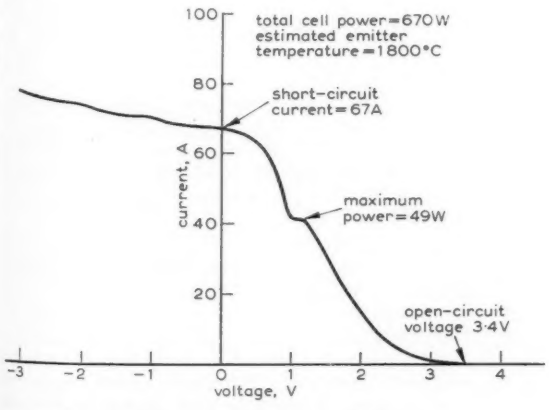
Thereby, the container tubes were dry internally and in contact with the reactor water externally; thus the coolant lines were thermally insulated from the reactor water, and the aluminum container cans were maintained at a low temperature.

Performance data

The performance of the cell during the experimental runs was quite satisfactory. Data were obtained for a variety of cell operating conditions and, for certain cell conditions, high electrical outputs and usable efficiencies were achieved.

Figs. 2 and 3 show typical cell-output characteristics obtained by varying the load resistance. As the resistance was increased, the voltage drop across the load increased and the current decreased. A maximum power-output point existed; in Fig. 2 it occurs at 1·22V and 40A, or 49W, and in Fig. 3 at 1·46V and 6·1A, or 8·9W. At these points, the total power generated in the emitter is 670W in Fig. 2 and 210W in Fig. 3, giving efficiencies of about 7·3 and 4·2% respectively.

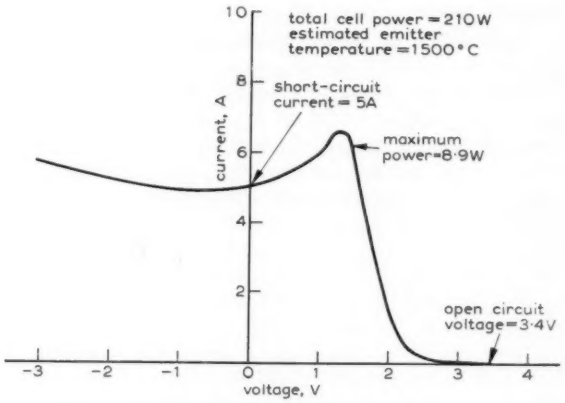
At higher power levels and emitter temperatures, higher efficiencies were obtained. For instance, at a total cell power of 900W and an estimated emitter temperature of 1900°C, an output of 60A at 1·5V was measured.



2 *Cell-output characteristics at about 1800° C*

This output of 90W (electrical) represented an over-all efficiency of 10% and a power density of about 12W/cm².

In addition to these runs, the cell parameters were varied over a broad range in other tests to explore the



3 *Cell-output characteristics at about 1500° C*

cell performance. During these experiments the output of the cell decreased, indicating some internal malfunction. The cell was removed from the reactor and taken apart in a hot cell.

Post-irradiation analysis

When the bottom of the collector can was removed, the cause of the decrease in cell performance was discovered: the evaporation of the cathode and condensation on the anode had caused a hard, uneven scale to form on the anode. This scale eventually became thick enough to short-circuit the cathode to the anode, both thermally and electrically, when the cathode was heated. The formation of this scale was not surprising in view of the high uranium content of the emitter. With only 5% zirconium carbide and 95% uranium carbide, the evaporation rate of the emitter was expected to be excessive.

The high-uranium-content emitter was used because a low neutron flux was available during the early experimental runs and because fabrication was simplified. Since the purpose of the test was primarily to obtain performance data and not to demonstrate long-term emitter stability, techniques for suppressing vaporization loss were not used.

The condition of the emitter was found to be substantially the same as it had been before irradiation. No significant changes in appearance were observed, despite the losses by evaporation. The absence of thermal-stress cracks was quite notable in view of the thermal shock incurred during operation: the emitter underwent

25–30 cycles involving temperature changes of 400° and 1900°C in time intervals of 1–5 min. In several instances the temperature was increased from 20° to 1500°C in about 1 min and from 1500° to 1900°C in 2 min. The over-all mechanical stability of the emitter was an outstanding feature of the test.

Significance

The success of this experiment has demonstrated several points in the development of thermionic-reactor systems. Power fluxes in excess of 10 W(electrical)/cm^2 of emitter surface could be attained, efficiencies of at least 10% were possible, adequate voltages occurred at maximum power, and the mechanical stability of the carbide emitters at high temperatures appeared promising. Design studies of thermionic reactors for space applications have shown that these power fluxes and efficiencies are in the range required for competitive systems.

The fact that the maximum electrical power occurred at an output voltage as high as 1·5V lends much encouragement to the use of cells within a reactor. If cell-output voltages were limited to 0·5–1·0V at power fluxes of interest in reactor design, the higher currents required would greatly increase the joule heating loss in both the emitter and the collector. To avoid this loss in efficiency, the cells would have to be more finely subdivided axially along the fuel element. This subdivision would increase the void space in the core and complicate the mechanical design of the fuel assembly.

At this early stage of research and development of thermionic cells, the performance of this in-pile cell is most promising. These experimental results are an encouraging step towards the successful development of nuclear-thermionic power systems. No attempt was made to incorporate such efficiency-enhancing features as thermal-radiation shields, optimum collector materials and collector-to-emitter spacing, or cascading schemes with thermoelectric materials. These techniques and future developments should certainly improve the performance obtainable from the thermionic cells.

Summary

A test of a prototype nuclear-thermionic fuel element was performed with very promising results. Although the test was of short duration, the power densities and efficiencies achieved are sufficient for many applications in space, marine and power-station plants.

Acknowledgments

The author wishes to acknowledge the capable advice of Dr. R. W. Pidd and the invaluable contributions of his co-workers, Dr. H. L. Garvin, Mr. F. D. Carpenter, and Dr. L. Yang, in the design and operation of the test.

England meeting of U.I.E. Executive Committee

For the first time, the Union Internationale d'Electrothermie has held the annual meeting of its Executive Committee in England; the meeting took place from the 24th to 27th April 1961.

The U.I.E. was formed in 1953 at the conclusion of an international congress on electro-heat, and now has a membership of 14 countries: Austria, Belgium, France, West Germany, Hungary, Italy, Japan, Netherlands, Norway, Poland, Sweden, Switzerland, Yugoslavia and the United Kingdom. The U.K. member is the British National Committee on Electro-Heat, the secretariat of which is provided by the British Electrical Development Association.

The U.I.E. has as its aim the establishment of permanent liaison between member-countries on all matters related to the industrial application of electro-heat, excluding those of a purely commercial aspect. Its secretariat is in Paris while its affairs are managed by the Executive Committee, composed of two permanent representatives from each member-country, which meets yearly in one of the member-countries.

The London meeting

This year's Executive Committee meeting was held in the offices of the Electricity Council in London, which were specially equipped for simultaneous translations of speech into English, French and German. There were full morning and afternoon sessions during the first two days of the meeting. On the third day, the 26th April, delegates and their ladies were taken on a motor-coach tour of the Midlands area as guests of the Midlands Electricity Board. There was an afternoon visit to a factory at Bromsgrove, Worcestershire, where they observed the production and use of induction-heating equipment.

Additional hospitality was extended by the Electricity Council, B.E.A.M.A., the London Electricity Board and the Central Electricity Generating Board, in the form of luncheons or dinners. The British National Committee on Electro-Heat handled all the arrangements for the committee meeting, as well as giving a dinner on the evening of the 24th April.

International congresses

The U.I.E. stages international congresses about every four years, during which papers are presented covering the whole field of electro-heat. The last congress, the 4th, was held during 1959 at Stresa, Italy, at which time 185 papers were presented. The full proceedings of the congress have now been published.

The 5th congress will be held at Wiesbaden, Germany, in the autumn of 1963. To promote fuller discussion, only 120 papers will be selected for inclusion by an international papers committee, including 20 from non-member-countries such as the United States and the Soviet Union. Preparations for this 5th congress were discussed at the London meeting of the Executive Committee. It has been agreed in principle that the 6th congress, in 1967 or 1968, will be held in the United Kingdom.

621.385 : 61.313.1

A NEW THERMIONIC GENERATOR

A thermionic generator capable of producing alternating current is described in this short account. This generator differs from previous models developed in the United States (one such model is described on p. 284 by Mr. R. C. Howard).

The author is Professor of Applied Electron Physics, Imperial College of Science and Technology, University of London.

Prof. D. GABOR, DR.-ING., F.R.S., MEMBER

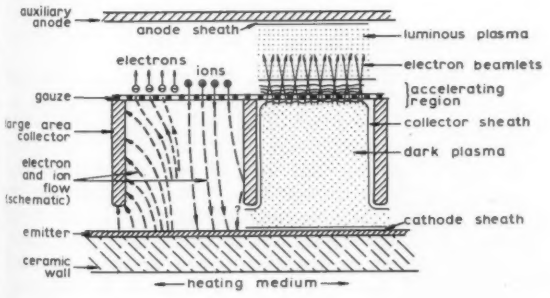
In thermionic generators, a heavy electron current must be passed through a gas space with as low a voltage drop as possible. The only practical way of achieving this is by neutralization of the electron space-charge by positive ions. In the new thermionic generator developed at the Imperial College of Science and Technology, London, the supply of ions is provided by a simple and highly efficient method, at a cost of only a few per cent. of the useful power. The principle of the device is shown in Fig. 1.

Description of generator

A large plane or cylindrical electron emitter is heated through a ceramic wall by the combustion products, or in a nuclear reactor directly by the fuel element. Opposite to the emitter a large collector electrode is arranged, with a honeycomb structure for increasing the electron-collecting area. As an example, the closest emitter–collector distance may be about 1 mm, while the cells measure, for instance, 4×4×4 mm. The collector structure is kept at a low temperature by contact with the cooling medium, not shown in Fig. 1.

A fine-mesh metal gauze closes the top of the collector cells and separates the main-discharge space from an auxiliary-discharge space, which supplies the ions. This second-discharge space contains a third electrode, called the auxiliary anode, which is held at a potential about 10 V above that of the collector and gauze. This voltage is sufficient for maintaining, in argon at a pressure of a few millimetres of Hg, a glow-like discharge. (In an argon–mercury mixture, 7·5 V is sufficient, in caesium 3 V.)

In this discharge a fine electron beam shoots through the centre of every mesh with an energy sufficient for ionization, and a fair proportion of the ions find their way through the gauze into the main-discharge space. The main discharge is therefore of the particularly simple type in which electrons are supplied from one end and ions from the other.



1 *Section through thermionic generator*

According to Langmuir's classical theory, the optimum ratio of the electron and ion current is that of the square root of the ratio ion-mass/electron-mass, which is 270 in argon, 494 in caesium, and 607 in mercury. The experimental results are even more favourable than this, because it was found that it was sufficient to let ½–1 % of the main-discharge current into the second space in order to get optimum compensation of the space charge, and it is unlikely that the ion current sent back into the main space was more than perhaps one-fifth of the electron current.

Terminal voltage

The main-discharge space is filled with a dense, nearly uniform, almost equipotential plasma with a remarkably low electron temperature of only a few thousand degrees. Owing to the large collector area, about three-quarters of the total electron-emission current flows from the emitter to the collector even at zero potential difference. At this current, the terminal voltage is equal to the difference between the emitter work function and the collector work function, less the ohmic drop inside the cell.

For operation of the emitter at 1500°–1800° C, and of the collector at 100°–300° C, 2·5 V for the first, 1 V for the second are suitable values, while the internal drop is of the order of 0·1 V. The typical terminal voltage of a thermionic generator at optimum load is therefore about 1·4 V. Less than 0·1 V is to be deducted from this for ion generation by the new method. For further details and for the mechanical design of a large thermionic generator, reference may be made to an earlier article by the author.*

Controllable device

The new generator differs in several respects from previous models developed in the United States by various authors. It does not require caesium (a chemically very active and difficult vapour that so far has been exclusively used because of its low ionization potential) to achieve full space-charge compensation at a lower cost, but uses argon, with an ionization potential four times higher. Moreover, it enables direct conversion of heat into alternating electrical energy. This is possible because the new generator is a controllable device: the main discharge can be cut off or restruck in a fraction of

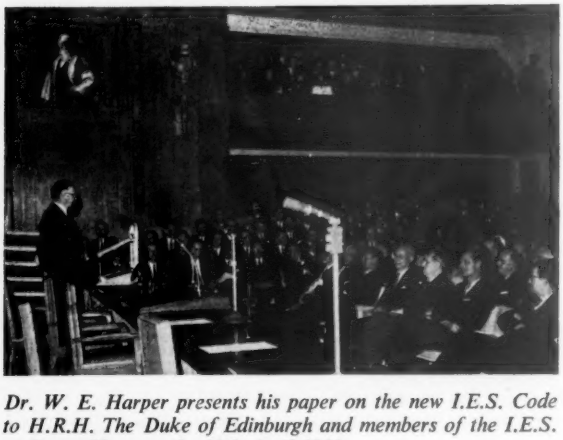
* GABOR, D.: 'A new thermionic generator', *Nature*, 1961, **189**, p. 868

a millisecond by cutting off or striking the auxiliary discharge. Two such generators operating in push–pull can therefore produce alternating current.

The efficiencies to be expected with the best materials so far known are of the order of 30% for d.c., and 21% for a.c., generation. Further development is almost entirely a matter of suitable materials. The ideal cathode material must have a low radiation emissivity and high electron emission, if possible 4–10 A/cm^2. The ideal collector must have a high reflectivity and low work function. Possible applications are in the fields of electric vehicles, large d.c. generators for electrochemical purposes, standby plants for taking the peak load, and 'toppers' for improving the efficiency of conventional power stations.

New recommendations for good interior lighting

At a meeting at Savoy Place on the 11th April 1961, honoured by the presence of H.R.H. Prince Philip, Duke of Edinburgh, The Illuminating Engineering Society introduced its new 1961 Code of Lighting. A certificate of Honorary Fellowship was presented to the Prince, who spoke of the problem of reconciling objective criteria of colour, direction and intensity of lighting with the criterion of acceptability to human taste.



Dr. W. E. Harper presents his paper on the new I.E.S. Code to H.R.H. The Duke of Edinburgh and members of the I.E.S. at Savoy Place on the 11th April 1961

The well presented lecture by Dr. W. E. Harper which followed surveyed the make-up of the new Code, its recommendations, and its effects on all kinds of interior lighting.

The I.E.S. Code was first issued in 1936 as 'Recommended values of illumination', and this was revised and published as 'The I.E.S. Code' in 1941. Since then, revised editions have been published, the last in 1955. The 1961 Code is a completely new edition, and the recommendations have been extended to cover wider aspects of lighting than in previous Codes.

Description of the Code

The new Code describes the principles of good lighting in Part 1. The aims of good lighting, planning the brightness pattern, revealing form and texture, and controlling glare are among the points discussed. For the first time a minimum amenity level of 15 lm/ft^2 is introduced, emphasizing the importance of lighting as a background to living as well as a working necessity. Emergency services; maintenance of lighting installations; lighting of passages, corridors, stairways, lobbies and entrances; and the appearance of coloured surfaces are other subjects considered in this part.

Part 2 deals with aspects of design. The computation and control of direct discomfort glare from artificial light sources have received particular attention. A new method for assessing glare, applicable to most of the important types of installation, has been developed. A 'glare index' is defined, and tables giving the initial glare index for the ten British zonal classifications are included The British zonal classification—a method of grouping fittings in terms of the direct light incident on the working plane—is described in I.E.S. Technical Report No. 2. The use of the glare-index data is discussed, and examples of the computation of the index are given.

Determination of the illumination levels for different occupations has been thoroughly investigated, as has designing for daylight. Designing for permanent supplementary artificial lighting is also examined.

Recommended values of illumination and limiting values of the glare index are scheduled in Part 3; these are related to different occupations and buildings. The different locations and tasks are grouped alphabetically within four sections: industrial buildings and processes; offices, schools and public buildings; surgeries and hospitals; and hotels, restaurants, shops and homes.

Many of the recommendations hold good whether the lighting is natural, artificial, or a combination of the two.

The Code finishes with two appendixes—a glossary and a bibliography.

Wigner-energy release at Harwell

A successful Wigner-energy release was carried out recently on the Bepo reactor at Harwell. The release began at 6.45 a.m. and was considered to be at an end 12¼h later. The release was carried out by externally heating the air-stream that is normally used to cool the reactor. The heated air was passed through the reactor for about 22h at about 9% of the normal operational rate of flow.

The reactor was run at a very low power level, about 50 kW, throughout the operation so that the burst-cartridge detection equipment could be used. The nuclear heating so produced was negligible in comparison with the air heating, and had no appreciable effect on the progress of the release. Additional instrumentation was provided so that the course of the release could be studied in detail.

The condition of the reactor graphite had been carefully investigated before the release, by sampling techniques.

Wigner energy is latent energy stored in the crystal lattice of graphite by displacement of atoms during radiation bombardment.

The Third Hunter Memorial Lecture

ELECTRONICS IN THE ELECTRICITY SUPPLY INDUSTRY

621.311.1 : 621.398 : 681.142

Electronic valves were first introduced into certain protective systems in the electricity supply industry some 30 years ago. Today, electronic techniques are applied throughout the industry. The automatic control by electronic equipment of a complete power system is now becoming possible.

This article is a shortened version of the Third Hunter Memorial Lecture, 'The application of electronics to the electricity supply industry', delivered before an Ordinary Meeting of The Institution on the 5th January 1961, and subsequently at a number of local Centres.

The author is Director of the Central Electricity Research Laboratories, Leatherhead.

J. S. FORREST, M.A., D.SC., MEMBER

A MODERN interconnected electricity supply network requires an equally extensive communication network for its efficient operation and control. In addition, apparatus is required for metering, protection, maintenance and testing. Electronic devices and techniques can be utilized for many of these functions with advantages from the point of view of compactness, speed of operation, reliability and economy in communication channels.

It therefore seems desirable to take advantage of new electronic developments by applying them to the supply system without delay, but a difficulty often arises because it is necessary to graft together two techniques with very different rates of development. On a new system it is particularly important not to adopt a conservative attitude, but to take advantage of the very latest proved electronic developments. On existing systems, however, it must be appreciated that much of the light-current equipment will inevitably appear to be relatively antiquated.

Introduction of electronic valves

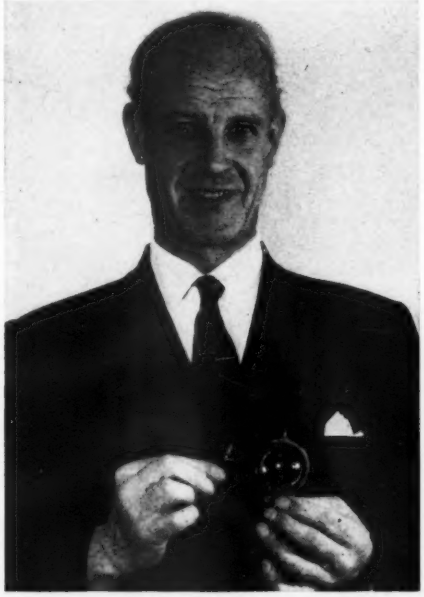
Electronic valves were first introduced into certain protective systems in the electricity supply industry some 30 years ago. Many supply engineers strongly opposed the introduction of valves on the grounds of their fragility and unreliability, and it must be admitted that for a long time the circuit designs, components and the constructional methods adopted were poor. Reliability was correspondingly poor, and promising developments were often discredited.

In recent years, the position has been much better following the introduction of stringent specifications and the realization that electronic equipment can be engineered to give a high degree of reliability. Today, electronic equipment has been introduced into most parts of the supply system, and the main applications are outlined below.

GENERATION OF ELECTRICITY

Ninety per cent. of Britain's electricity is generated from coal, and the transport of 45 million tons a year from the pits to the power stations gives rise to various problems. For example, where should the coal be purchased, bearing in mind the varying cost of coal, cost of transport from pit to station, and the different station efficiencies? An analogue computer has been designed to solve this problem, so that immediate action can be taken to deal with any change in conditions at the pits or in the electricity system.

A prototype computer able to deal with five stations and 20 pits is shown in Fig. 1. In a large system the possible number of routes increases rapidly, and a correspondingly larger computer is required.

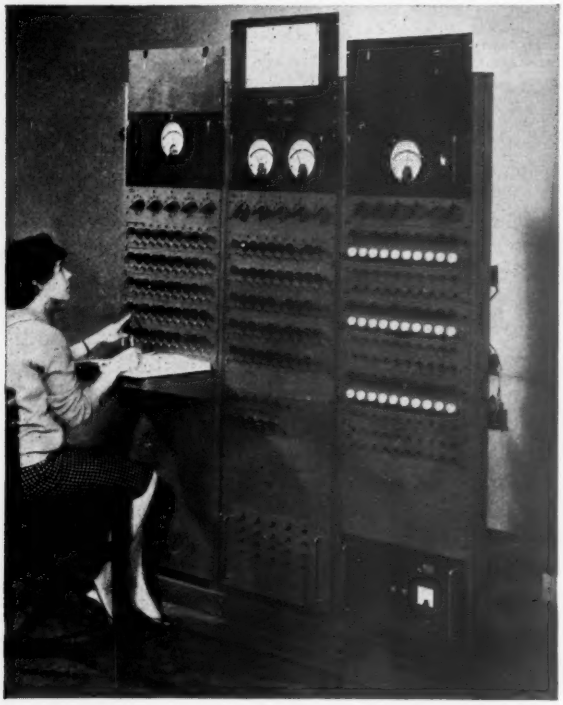


The Lecturer, Dr. J. S. Forrest, showing a microminiature triode and an early receiving valve

In the boilerhouse, closed-circuit television is finding increasing application. The burners and the furnace flames can be viewed by a water-cooled periscope and television camera, and the picture displayed on the control panels. This gives the control engineer continuous information on the conditions in the combustion chamber, such as turbulence or loss of ignition. Television is also used to provide a remote indication of boiler-drum water level. Other applications include the viewing of the slag tap-hole in a cyclone boiler and, in nuclear reactors, the examination of areas where the intensity of radiation is high.

Other and simpler methods of obtaining a remote indication of water level are also being considered.

For example, one device takes the form of a series of electrodes inserted at different levels in the boiler drum and connected to transistorized level detectors operating a display of red and green lamps, which can be repeated



1 *Coal-transportation computer*

wherever necessary. A high degree of reliability is achieved, and a faulty channel is immediately evident.

Dust emission and pollution

In order to monitor dust emission continuously, an instrument has been developed for installation in the power-station flues (Fig. 2). This device measures photoelectrically the obscuration of a surface by dust particles settling on it from the gas stream. In this way, a realistic measure of the nuisance caused by the emission of the dust is obtained. The surface is blown clean at regular intervals by compressed air, and a new measurement is made and recorded on a chart. The operator can see immediately the effects of soot-blowing or inefficient precipitator operation.

The combustion of coal produces sulphur oxides from the pyrites present in the coal, and in order to assess the effect of power stations on atmospheric pollution, it is necessary to measure the amount of sulphur dioxide in the air near the station. A very sensitive instrument is required, and the apparatus developed for this work will indicate 1 part of sulphur dioxide in 10^8 parts of air. To obtain data on the dissemination of gases from chimney-stacks, it is useful to measure the sulphur dioxide concentration at various heights, and for this purpose a sulphur dioxide radio-sonde has been developed that can be flown from a captive balloon and will transmit the observations to a ground station.

Computing techniques

On the British Grid system it may be necessary to pick up load on a winter's morning at a rate of about 100 MW/min, and the quick starting-up of plant is of the utmost importance. Accordingly, there is much interest in automatic methods of starting-up plant which would give the maximum speed compatible with safety. These methods involve essentially a master controller, or computer, that receives information from all parts of the plant and initiates operations at the right time in a sequence determined by the computer programme.

Computing techniques are also being used for logging operational data in power stations. The log of readings, which was once laboriously and slowly taken by an operator, can now be printed automatically in a few minutes and any deviations from preselected values printed in red or made to sound an alarm. Averages or standard deviations can be computed and a continuous record of station performance provided. In nuclear reactors, some 2000 temperatures can be supervised continuously. Automatic control of the whole power station is now becoming feasible.

CONTROL AND COMMUNICATION

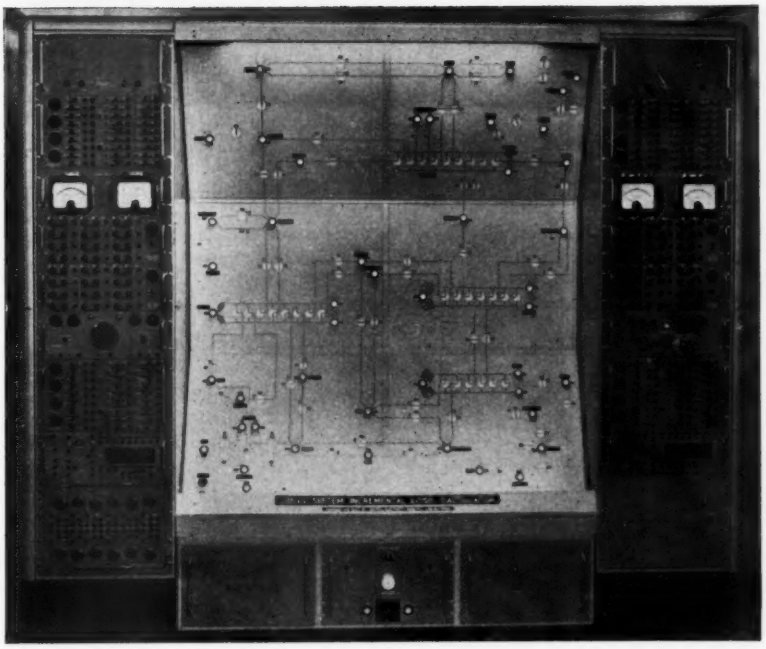
Various forms of analogue computer, from simple resistance networks to more refined electronic devices that simulate the system more accurately, have been used to determine short-circuit currents, load flow, and stability in different operating conditions. A more recent development is the incremental-loss calculator, which provides information on the cost of supplying an increase in load, taking into account the cost of line losses. This enables the control engineer to determine the most

2 *Flue-dust monitor*

economic way of loading the system. Fig. 3 shows the incremental-loss calculator that is used for the 275kV system loading.

The system load is significantly affected by weather conditions. The heating and lighting loads are determined largely by weather—a drop in temperature of 20°F may in winter cause an increase in load of several thousand megawatts. Moreover, breakdowns caused by thunderstorms, fog or ice-loading may necessitate a redistribution of load.

Therefore, there has been a need for instruments to give the control engineer special information on weather conditions. For example, daylight-illumination meters are installed at various positions, and thunderstorm recorders are used at the main control centres. The thunderstorm recorder is basically a radio receiver that records on a chart the atmospherics due to lightning flashes. Its sensitivity is adjusted to record thunderstorms within a radius of 100 miles. It gives the control engineer definite evidence of the outbreak of a thunderstorm and some indication of its distance and severity.



3 *Incremental-loss calculator for 275kV system*

Communication circuits

Communication circuits may take the form of land lines, aerial cable suspended from transmission towers, pilot cores in earth wires or in h.v. cables, carrier circuits on power lines, or radio links. V.H.F. radio is now widely employed in transmission and distribution systems for emergency operation, maintenance, and consumer service. Some years ago, a major power station, isolated by floods, was kept in communication with control only with the help of v.h.f. radio. At present, the supply industry operates some 200 fixed stations and over 3000 mobile stations.

Other possibilities have been suggested, such as the use of hollow h.v. conductors as waveguides or the launching of surface waves along line conductors. Very difficult practical problems would have to be solved before either of these schemes became attractive, and at present the increased use of power-line carrier, u.h.f. and microwave links seems to offer the best way of improving communication facilities.

With improved instruments for the measurement of conditions throughout the system and an adequate data-transmission network, together with data-handling equipment at the control centres, it is feasible to control the system automatically. In addition, as has been mentioned, the generating-station operation can be controlled automatically, and so the realization of a completely automatic power system becomes possible.

METERING AND PROTECTION

Electronic summation metering has recently been developed with the objects of obtaining higher speeds of impulsing and improving accuracy by eliminating contacts. Each meter has a light-operated photo-transistor impulse transmitter which has no mechanical contacts. The impulses from the meters operate bistable stores that are scanned sequentially, and the impulses are transferred to the summator. Transistor circuits are used for the stores and the scanning equipment, and excellent reliability with a minimum of maintenance should be achieved.

Electronic voltage transformers have been proposed in which an h.v. capacitor, such as a tapped bushing or a carrier-current capacitor, feeds a precision amplifier whose output supplies the meters or relays. An amplifier with a high input impedance and adequate output has been designed that reproduces the input accurately in magnitude and phase. The performance of the equipment is limited, however, by that of the h.v. capacitor. The output from a tapped bushing, for example, varies with weather conditions and may introduce errors of as much as 10%.

For current and power measurement, the Hall effect in semiconductors has been utilized, but such methods still involve the provision of expensive insulation to

earth. Accordingly, it has been proposed that the reading from the power- or current-element at high voltage should be used to modulate an infra-red, radio or ultrasonic beam, transmitted to a receiver at earth potential.

Fault protection

Some form of fault protection is essential in all transmission and distribution networks to switch out the faulty section, and that section only, in the event of a disturbance. Many ingenious systems of protection have been devised, but in general it is the function of the protective gear to measure the voltage and current conditions in the circuit and initiate tripping, sometimes after a deliberate time-lag, if a fault is indicated. The equipment must be highly reliable and should function without fail, even though it may have to operate only once a year.

Conventional protective relays usually take the form of more or less complicated electromechanical relays incorporating attracted armatures, moving coils, induction discs, gearing, adjustable weights and various contacts. With skilled maintenance and testing, a high standard of service performance is achieved, but there would seem to be much scope to engineer protective systems *ab initio* on a solid-state basis.

All the required functions can be carried out by electronic circuits and static components, such as transistors, rectifiers and magnetic amplifiers, with a great reduction in the number of moving parts and electrical contacts and freedom from mal-operation due to mechanical vibration and shock. The equipment could be designed on a unit system with easy replacement of units, and the present standard of reliability could be retained with much less maintenance and with much more compact equipment.

Many protective systems depend on the transmission of a signal from one end of the circuit to the other. Any reliable communication channel can be used for this purpose, but the possibility of using u.h.f. or microwave links is attractive, especially for circuits across rivers or estuaries.

A recent protective system for one of the Central Electricity Generating Board's circuits makes use of a microwave link between the line terminals. It is a phase-comparison transistor system using a transmission frequency of 7300 Mc/s over a distance of 13 miles. Some 20 communication channels are available, and this number could easily be increased tenfold if required. The equipment is duplicated, with automatic changeover in the event of failure.

MAINTENANCE AND TESTING

The most interesting aspect of maintenance is the detection of incipient faults before complete breakdown occurs in service. This usually involves making sensitive measurements in rather difficult site conditions, and there is much scope for the application of electronic techniques in this field.

Most electrical breakdowns are due to a failure of insulation, and a measurement of the electrical characteristics of the insulation can detect the failure at an early stage. A measurement of insulation resistance will indicate deterioration of insulation owing to the ingress of moisture—probably the most common cause of failure. For this purpose it is necessary to measure insulation resistance up to 100000 MΩ at several kilovolts.

Another form of insulation deterioration is erosion due to electrical discharges in voids, which may lead to breakdown between layers in bushings of the capacitor type. This kind of deterioration can be detected by a capacitance measurement.

An electronic measuring set has been designed to measure both insulation resistance and capacitance. A feature of the instrument is that it has a log scale of insulation resistance, so that a range of 10–100000 MΩ at 5 kV d.c. can be covered on a single scale. The capacitance measurement is made by an a.c. bridge, using the meter as a null instrument. The equipment is portable and ruggedly built for site use. Many breakdowns in service have been forestalled by making routine measurements with such instruments.

In maintenance and testing operations, it is frequently necessary to check that a circuit is not live. A lightweight battery-operated instrument recently developed for this purpose is shown in Fig. 4. Important features of this instrument are that it gives an unambiguous indication and that it fails to safety. It is particularly useful for checking orifice insulators on metalclad switchgear.

4 *Live-conductor detector*

A similar instrument mounted on the jib of a crane is now being developed to give an alarm if the jib approaches dangerously close to live overhead-line conductors. Such a device should help to reduce the number of accidents that occur when cranes are working near overhead-line conductors.

Faulty-joint detector

Faulty joints are a not infrequent cause of breakdowns on overhead lines. As a result of corrosion or poor workmanship, the joint develops a high electrical resistance, overheats and fails mechanically. A measurement of d.c. resistance will detect this trouble, but involves taking the line out of service and getting access to the joint.

It would be a great convenience if faulty joints could be located with the line alive. Infra-red faulty-joint locators, which make a remote measurement of the temperature of the joint under load, have been used for this purpose (Fig. 5). The joint is sighted through a telescope and the surface temperature registered on the meter—it will detect a joint at a temperature of 80°C at a distance of 50m.

5 *Infra-red faulty-joint locator*

Recording and location of breakdowns

When a breakdown occurs, it is often difficult afterwards to discover the sequence of events and the primary cause of the trouble. Equipment that will automatically record the system currents and voltages during the fault is invaluable for post-mortem investigations. Automatic oscillographs initiated by the fault have frequently been used for this purpose, but have the disadvantage that the onset of the fault is necessarily missed.

Clearly, apparatus is required that records continuously and wipes out the record if conditions are normal. Magnetic recorders are ideal for this purpose. These instruments have adequate frequency response and can be played back into a cathode-ray oscillograph. The display can be photographed so that oscillograms showing the waveforms and magnitudes of the currents and voltages, and the duration of the disturbance, can be kept for analysis and permanent reference.

For recording short-duration voltage surges, an electronic instrument has been designed in which the surge, of a few microseconds' duration, is lengthened by pulse-lengthening circuits to enable the peak value to be registered by a moving-coil meter. When a surge is registered, the meter reading is photographed automatically by a cine-camera, so that statistical information on the frequency of occurrence of surges of various amplitudes can be collected. For transient recording, the recently developed cathode-ray tubes with screens that can store the waveform for some days are likely to have useful applications.

Another important requirement is to locate the position of the breakdown when it occurs. This involves the continuous monitoring of a live system, and an ingenious instrument, operating on the pulse-echo-reflection principle, has recently been developed for this purpose. A pulsed radio-frequency of 1 Mc/s is employed, and 5μs pulses at 5ms intervals are applied to the line through an h.v. capacitor as used for carrier-current coupling.

Essentially the instrument detects variations in the r.f. impedance of the circuit and displays these on a cathode-ray-tube screen. Remarkable sensitivity is achieved, and the position of tension towers, variations in conductor spacing owing to gusts of wind, and deposits of ice on the conductors can be detected. A breakdown can be located with an accuracy within a few spans in a 100 mile line.

FUTURE DEVELOPMENTS

It must be emphasized that almost any degree of supervision, remote control or automatic control is now technically possible, and it is only a question of deciding whether it is financially worth while. Apart from the financial argument, however, the increasing complexity of systems and the more stringent operational requirements of modern plant may necessitate more-sophisticated control techniques. It is quite possible for a shift engineer to log some tens of readings every hour, but if a thousand readings need to be checked every minute, and any discrepancies noted, an automatic data-logger is the only solution.

In addition to the control of the system, it is quite possible that electronic devices will play a major part in generating electricity in the future, and it is not too fantastic to conceive what may be described as an all-electronic power system.

Electricity might be generated in magnetohydrodynamic generators working at a few thousand degrees Celsius or in more-advanced thermonuclear machines operating at several hundred million degrees Celsius and transforming a pound of cheap fuel into a million kilowatt-hours. Transmission would be by h.v. alternating or direct current, the rectification and inversion

being carried out by controlled solid-state rectifiers. Communication would be by microwave links, using solar cells for power at repeater stations, and would provide numerous channels for data transmission, protection and remote control.

The system data would be transmitted to a central computer that would issue instructions to generating stations, selecting the station on the basis of its costs at that moment and the associated system losses. Fault conditions anywhere in the system would be signalled through the data-transmission channels to the central computer, which would carry out the remote switching necessary to restore supplies in accordance with a logical programme. When necessary, the central computer would initiate automatic start-up or shut-down of a set with the help of the local-station computer.

A human note

What effect will the all-electronic system have on the men who run the system? Fewer men will be required for routine duties and menial tasks, but many more electronic engineers and technicians will be necessary. It will be a long time before the machine can replace the experienced and resourceful control engineer, but he will have to adapt himself to new conditions and learn to formulate programmes for the machine and to delegate operational responsibility, not to other men but to equipment.

Summary

Electronic techniques are widely used in electricity supply systems to provide efficient methods of communication, data transmission, control, metering, protection and testing.

Electronic equipment for the automatic control of generating stations and transmission networks is being developed, and the automatic control of a complete power system is now becoming technically feasible.

In the future, electronic devices may also play an important part in the generation of electric power.

Activities of the North of Scotland Hydro-Electric Board

THE North of Scotland Hydro-Electric Board are to use submarine cables from their mainland Grid to supply the growing demand for electricity on the island of Islay. As well as allowing the existing supply network on Islay to be supplemented, this will enable a supply of electricity to be made available on the island of Jura.

Supply to Islay and Jura

The submarine cable will cross from the mainland to Jura (6¾ miles) and from Jura to Islay (1¼ miles). In addition, there will be 42 miles of overhead line supported on wooden poles. The work will be carried out in 1961.

Between the mainland and Jura the maximum depth of sea is 84 fathoms. For this crossing, two 3-core 0·1 in.^{2} gas-filled 33 kV cables will be used. The maximum water pressure on the cables will be 224 lb/in.^{2} The internal gas pressure of the cables will be maintained at 250 lb/in.^{2} The crossing from Jura to Islay is relatively shallow, being 14 fathoms deep. In this instance, the link will be two 0·1 in.^{2} 3-core pre-impregnated paper-insulated high-speed-lapped solid-type 33 kV cables. The remote location of the landing sites and the relative shallowness of the crossing decided the type of cable for this link.

Economics of mainland connection

Islay has a load of about 2000 kW. This is met, at present, by Diesel generation at the Bunanuisg power station at Bowmore, where there are three 600 kW and two 265 kW sets.

The possibility of a mainland connection to Islay was examined when the 33 kV system on the Argyll mainland was reinforced by building a 132 kV line along Loch Fyneside to a 132/33 kV bulk supply point at Port Ann near Lochgilphead. A detailed analysis showed that by 1961 it would be no more expensive to take supply from the mainland over a 33 kV extension to Islay than to continue Diesel generation on Islay. After 1961, the mainland connection will become progressively more favourable.

Routing of connection

The first stage of the submarine-connection scheme will consist initially of a single-circuit overhead line from the Port Ann substation to Keills near the mouth of Loch Sween on the west coast, whence the duplicate submarine cables will be laid to the island of Jura.

Use will be made of three miles of existing 33 kV line from the Port Ann substation, as well as five miles of 11 kV line between Tayvallich and Keills which is to be uprated to 33 kV. On Islay a 33 kV overhead line will run from the submarine-cable landing point to Bowmore. The new line will terminate at the Bowmore generating station, with a connection to the busbars through a 3·5 MVA transformer.

Lednock power station

The Board have brought into operation the Lednock power station in Perthshire. The situation of the station, 1160 ft above sea level, is one of the highest in the Highlands. It has a capacity of 3000 kW and an estimated average annual output of 5 million kWh.

Water to operate the Lednock power station is stored in Lochan Breaclaich, a small loch in the hills between Loch Tay and Loch Earn which has been enlarged and its level raised to 1453 ft above sea level by a dam 1400 ft long and 80 ft high. The horizontal Francis turbine in the power station, which works under a gross head of 300 ft, drives an induction generator.

LETTERS TO THE EDITOR

INDUSTRIAL NOISE HAZARDS AND THEIR PREVENTION

Dear Sir—In all the textbooks I have read and in all the lectures I have attended, the definition of the decibel has been the same:

$$\text{gain in decibels} = 10 \log_{10} \frac{P_2}{P_1}$$

$$\text{and attenuation in decibels} = -10 \log_{10} \frac{P_2}{P_1}$$

where P_1 and P_2 represent the input and output powers respectively. I am, by now, accustomed to the misuse of the term 'decibel' in the national Press, but when it is used incorrectly in the *Journal* I feel it is time to protest. In the March 1961 *Journal*, p. 151, Dr. D. E. Hickish talks of 'meaningless noise of high intensity (in the region of 100dB)'. According to the definition above, this means sound 10^{10} times as loud as some other sound. But what is this other sound? Is it that of a pin dropping or that of a racing car accelerating at its maximum? We are not told what the *reference sound level* is, and without this information it is useless to talk of sound levels of xdB.

Dr. Hickish later mentions the effects of a reduction in noise level from 99 to 89dB. Although the figures individually mean nothing, taken together they mean that the sound has been reduced by 10dB, or that the original sound has been reduced tenfold.

Please let us hear no more of the decibel as a unit of power or sound intensity (there are already units for these quantities), and if it must be used let a reference power, voltage, current or noise level be stated.—Yours faithfully,

R. G. RODWELL

Coton House
Churchover
23rd March 1961 Rugby, Warwickshire

[Dr. Hickish writes: The decibel unit used in noise measurement is derived from the expression: sound pressure level,

$$\text{dB} = 20 \log_{10} \frac{P}{P_{\text{ref}}},$$

where P is the observed sound pressure and P_{ref} is the reference sound pressure. The normal reference pressure is 0·0002dyne/cm^2, as stated in my article on p. 152.

I am afraid that, in his interpretation of a sound pressure level of 100dB, Mr. Rodwell has confused the physical intensity of a sound, as defined above, with its loudness, which is a subjective characteristic. There is no simple relation between the physical characteristics of a noise and its loudness. Taking, however, the example of a pure tone with a frequency of 1000c/s, an increase in intensity of 10^6 times, from 40 to 100dB, would happily only increase the loudness by a factor of about 55, and not 10^6 as suggested by Mr. Rodwell.

In my quotation of the observed effects on performance of a reduction in noise level from 99 to 89dB, the figures taken individually have a great deal of meaning. It would certainly not be expected that a tenfold reduction in intensity from 59 to 49dB would produce a comparable change in film-breakage rate.

To forestall further challenge in regard to the use of the decibel in Fig. 1 of my article as a unit of hearing loss, I hasten to inform you that my reference level, shown for simplicity as 'normal hearing', is in fact that defined in British Standard 2497: 1954.]

Industrial noise hazards and their prevention
R. G. Rodwell, B.SC.(ENG.), GRADUATE
An evolving universe?.....O. E. Jones, GRADUATE
Physicists and The Institution.....D. W. Hill, M.SC., ASSOCIATE MEMBER
Mutato nomine.....J. C. Read, D.SC., MEMBER
Ampère or Biot–Savart?.....Instr.-Cmdr. P. Miller, M.A., R.N., ASSOCIATE MEMBER
A scientific–humanist approach....H. G. Gange, GRADUATE
Parallel impedances.....H. Horwood, ASSOCIATE MEMBER

AN EVOLVING UNIVERSE?

Dear Sir—Prof. Martin Ryle's observations (March 1961 *Journal*, p. 155) on the disposition of star formations indicates that the detectable stars form a fragment of skin on a gigantic bubble that is still expanding because of an explosion billions of years ago.

Such an explosion could be caused by dying solar systems gravitating to some common centre. The immense pressures at the centre of the mass would cause atomic disintegration and the release of energy. Will a series of explosions occur as sections of the skin lose velocity and draw together?

It is interesting to speculate on the degree of atomic disintegration occurring in such an explosion. If particles of micro-matter were thrown off at speeds exceeding the speed of light, it might be possible to account for phenomena hitherto unexplained.—Yours faithfully,

OWEN JONES

Inglewood
Burfield Road
25th March 1961 Old Windsor, Berks.

PHYSICISTS AND THE INSTITUTION

Dear Sir—May I take this opportunity of congratulating you on the Foreword 'Physicists and The Institution' (March 1961 *Journal*, p. 139). As a physicist and a Corporate member of The Institution, I find it pleasant to see further proof of co-operation between those with much in common in their professional skills.

This aspect is particularly interesting to me as a senior lecturer at the Royal College of Surgeons. Here I work,

having equal status, with enthusiastic doctors in a busy research department. The research problems to be solved must come first. With regard to the members of a team, as the Foreword said, 'within a few years of graduation it is often difficult to observe, nor is it of great interest to know, from which particular undergraduate discipline they have individually emerged'.—Yours faithfully,

D. W. HILL

Royal College of Surgeons of England
29th March 1961 London W.C.2

MUTATO NOMINE

Dear Sir—I feel that Mr. S. A. Vincze (March 1961 *Journal*, p. 157), in reviving the old proposal for international adoption of the word 'mutator' in place of 'rectifier', 'inverter', 'convertor', etc., is asking us to retrace our steps.

For such a widely used article it is highly desirable that the name adopted should be acceptable to the largest possible body of engineering opinion. The present terms, which Mr. Vincze wishes to replace, are those given in the International Electrotechnical Commission Vocabulary (2nd edition), Group 11, Static convertors, 1956, p. 1. The preface to the vocabulary gives a brief account of the many bodies represented or consulted when it was being composed.

In addition, the specialist committee of the I.E.C. which was dealing with these devices, and on which both manufacturers and users from all the principal industrial countries were represented, discussed this term 'mutator' from time to time between the end of the recent war and the publication of the vocabulary, and it was always clear that there was no support for its use. 'Mutator' is not recognized in the vocabulary even as an alternative, either in English or in any of the other languages for which translations are given.

Obviously a change might be worth considering if there were sufficient reasons for it. The reasons given by Mr. Vincze are (a) that (to take the principal example) 'mutator a.c.–d.c.' is thought preferable to 'rectifier' (perhaps on grounds of simplicity or brevity?), and (b) that 'convertor' should be reserved for rotary convertors. Are these really sufficient grounds? Would we not be better occupied in securing the maximum acceptance of the terms already standardized after so much discussion?—Yours faithfully,

J. C. READ

Divisional Consultant—Rectifiers
Associated Electrical Industries Ltd.
Heavy Plant Division
30th March 1961 Rugby, Warwickshire

AMPÈRE OR BIOT–SAVART?

Sir—I always enjoy Mr. P. Hammond's letters and articles. While I have no doubt that his statements (March 1961 *Journal*, p. 157) about Ampère are correct, when I was a student I always associated Ampère's law with magnetic shells and circuital theorems, cf. Pidduck and Abraham.

I quote as I learned: $\int H ds = 4\pi i$ or curl $H = 4\pi i$

Mr. Hammond does not mention vector potential, unless he considers this a variation of 'Biot–Savart'; what name is associated with vector potential?—Yours faithfully,

P. MILLER

Curdridge Hill
2nd April 1961 Nr. Botley, Hants

[Mr. Hammond writes: I agree with Cmdr. Miller's view that Ampère's great contribution to electromagnetism lies in his discovery that the magnetic field of a current loop is indistinguishable from that of a magnetic shell bounded by the loop. This discovery leads at once to the circuital law $\oint H ds = i$, which can therefore very properly be called Ampère's law. If I had to answer my own question at the end of the letter published in the March *Journal*, I should suggest that we call $H = \dfrac{i\,ds \sin\theta}{4\pi r^2}$ Laplace's rule and $\oint H ds = i$ Ampère's law.

The story behind the concept of vector potential is a fascinating one. Faraday, Neumann, Weber, Kirchhoff, Kelvin and supremely Maxwell all made valuable contributions to this story, but it would require more space than is available in a correspondence column to give a coherent account of it.]

A SCIENTIFIC–HUMANIST APPROACH

Dear Sir—The need for achieving a synthesis of science and the humanities is being widely stressed at present. The humanist is primarily concerned with experience and with the macroscopic aspect of things. The question arises as to how far this viewpoint is compatible with the findings of science.

A fundamental role is played in modern science by the atomic concept of matter. In many ways, the world of the atom runs counter to traditional knowledge and experience: its non-causal, colourless, lifeless characteristics are foreign to the outlook of the humanist. If the world of elementary particles described by the atomic scientist actually exists, the possibility of achieving an integrated scientific–humanist world concept is remote.

The reality of the subatomic realm is widely accepted. Through the media of radio, television and the Press, atoms and their constituent particles are presented to the general public as real entities; tracks of elementary particles have been recorded photographically; the practical achievements of electronic and atomic engineering seem to emphasize that the world of the atom is more than a mere figment of the imagination.

These claims to reality should, I think, be carefully examined. What does science actually say on the subject? The answer appears to be—nothing! 'Science', wrote Eddington [EDDINGTON, A. S.: 'The nature of the physical world' (Cambridge University Press, 1929), p. 259], 'has nothing to say as to the intrinsic nature of the atom'! Science does not claim

to pronounce on the absolute nature of things, and does not require that the subatomic realm should have a real existence. The atomic concept of matter is a convenient working hypothesis that may be superseded when any other, operationally more suitable, is found.

The elementary particles that arise in the special conditions of the vacuum tube appear real enough, but it is not necessary (though it may at present be convenient) to believe that the particles exist universally, in all matter in all conditions.

Indeed, so many new particles have been discovered in recent years that even the specialist may perhaps be forgiven for doubting their fundamental character.

There are indications that scientific thought is today tending towards the development of a more comprehensive, liberal approach. In order to facilitate this process, it is, I think, desirable that the atomic concept of matter should be seen in its right perspective: as a useful working hypothesis, and not as a description of reality.

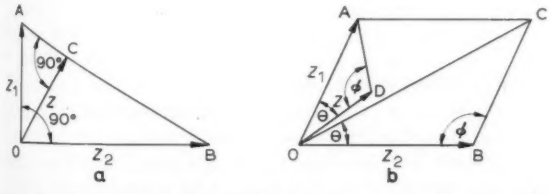
A new method of approach may well prove better suited than the existing to investigate the nature of the sub-material, dynamic realm underlying the phenomenal world.—Yours faithfully,

H. G. GANGE
42 Glandon Drive
Cheadle Hulme
13th April 1961 Cheadle, Cheshire

PARALLEL IMPEDANCES

Dear Sir—In the course of my work involving busbar-impedance calculations, I evolved a simple graphical method for finding the resultant of two parallel impedances (*Electrical Review*, 1946, **138**, p. 846).

At that time the method was not entirely satisfactory, in that it was only fully graphical for impedances exactly 90° apart. For other displacements the method required a certain amount of arithmetic.



1 *Resultant impedance Z in magnitude and direction for parallel impedances Z_1 and Z_2*
a Impedances 90° apart
b Impedances any angle apart
ODA and OBC are similar triangles

However, while I was on holiday on Mount Carmel in February 1961, the fully graphical solution for any angle came to me, and is presented in Figs. 1a and 1b.

The method is, of course, based on the fundamental equation for the solution of two parallel impedances Z_1 and Z_2, namely $Z = Z_1Z_2/(Z_1 + Z_2)$. For non-inductive impedances the calculation is simple arithmetic, and graphical methods are seldom used. For inductive and/or capacitive impedances the calculations are more complicated, and the graphical method is much quicker and simpler.—Yours faithfully,

H. HORWOOD
107 Slough Lane
19th April 1961 Kingsbury, London N.W.9

THE *MONARCH* SAILS

RECENTLY, H.M.T.S. *Monarch* sailed from Greenwich to Scotland to begin laying the first section of the Commonwealth cable, Cantat. This section will be a single transatlantic telephone-cable system designed to provide 60 circuits between Scotland and Newfoundland. There will be an extension to the mainland of Canada by a further submarine cable to the south bank of the Gulf of St. Lawrence.

Monarch was built in 1946 and is the largest cable-laying vessel in the world today. She has four cylindrical cable tanks, 41 ft in diameter, with a total coiling capacity of 125000 ft^3. The ship is fitted with the latest navigational aids and has echo-sounder equipment that gives sounding information in ocean depths up to 4¾ miles. She is capable of 14 knots.

Cantat will have 90 repeaters and seven submerged equalizers in the main crossing from Scotland to Newfoundland, a distance of 2100 nautical miles. The cable for this project is a radical departure from previous types of deep-sea cable in that (except for the shore ends that are in shallow water) it is unarmoured and very much lighter in weight. The strength of the cable lies in the high-tensile-steel strand at its centre within the inner cable conductor.

H.M.T.S. Monarch at Greenwich, about to sail to lay the Cantat cable

MEETINGS OF THE INSTITUTION COUNCIL ON THE 6th and 27th APRIL 1961

THE following summary of reports received and decisions reached by the Council of The Institution at their meetings on the 6th and 27th April 1961 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meetings, as some items are to be the subject of further discussion by the Council.

6TH APRIL 1961

Fellowship of the Royal Society

The Council expressed their pleasure at the recent election of Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.), MEMBER, as a Fellow of the Royal Society and directed that a letter of congratulation be sent to him on their behalf.

Regulations for the Electrical Equipment of Ships

The President welcomed Mr. G. O. Watson, MEMBER, Chairman of the Committee on Regulations for the Electrical Equipment of Ships, who was attending by invitation to present for the Council's approval a draft 4th edition of the Regulations for the Electrical Equipment of Ships. After Mr. Watson had introduced the new edition, the Council had pleasure in authorizing its promulgation and, in doing so, paid tribute to the valuable work done towards its preparation by Mr. Watson personally, the members of his Committee and the technical staff of The Institution.

Thanking the Council, Mr. Watson pointed out the appropriateness of this new edition's being promulgated during the Presidential year of Sir Hamish D. MacLaren, until recently the Director of Electrical Engineering at the Admiralty.

Membership

The Council gave final confirmation to the election of those candidates whose names had been published with the February 1961 *Journal*, to become effective from the 1st April 1961. Taking these into account, the total membership at that date was 47422.

Accounts for 1960

In the Honorary Treasurer's absence Mr. C. T. Melling, Chairman of the Finance Committee, introduced the audited accounts for 1960 and read the Honorary Treasurer's report on the finances of The Institution for that year. These were adopted and approved for inclusion in the Annual Report.

It was agreed to refer to the Finance Committee the possibility of including, at the end of the accounts in future years, a table summarizing the over-all financial position of The Institution for the previous years.

Hong Kong University—Jubilee Celebrations, September 1961

On the recommendation of the General Purposes Committee, the Council accepted a proposal from The Institution of Civil Engineers that Prof. J. F. Baker be invited to represent the three engineering institutions at the Jubilee Celebrations of Hong Kong University in September 1961.

Study visit to France

The Council approved a recommendation of the Education and Training Committee that Prof. M. W. Humphrey Davies, M.SC., MEMBER, and Mr. N. C. Stamford, M.SC.TECH., MEMBER, represent the Council during a study visit to France, arranged by the Regional Advisory Committee for Technological Education (London and Home Counties), in October 1961.

Institution Examination Parts II and III

Arising out of a suggestion from the Southern Centre Committee, the Examinations Committee recommended that the names of the examiners and moderators for Parts II and III of the Institution Examination be published in the *Journal* as a group, without specifying the subjects with which individual examiners and moderators were associated. The Council agreed to this proposal.

Prizes

On the recommendation of the Examinations Committee, the Council approved the list of Institution Prizes to be awarded to those who had gained Higher National Certificates and Diplomas in 1960. Other awards were the Page Prize to Mr. J. Mildoon of the Dudley and Staffordshire Technical College, the Goldup Prize to Mr. J. E. Eyres of Southall Technical College, and the Henry Nimmo Prize to Mr. J. Foster of the South Berkshire College for Further Education, Newbury.

The Institution of Engineers, Ceylon

An application from the Institution of Engineers, Ceylon, to take part in the Engineering Institutions Examination Part I had already been approved by the Standing Committee and was now referred to the Councils of the Institutions of Civil, Mechanical, Electrical and Municipal Engineers for their agreement in accordance with clause 4 of the constitution and duties of the Standing Committee. On the recommendation of the Examinations Committee, the Council gave this approval.

Annual Report

Copies of the draft Annual Report of the Council, in proof form, as prepared by the Annual Report Drafting Committee, were placed on the table, and it was agreed that members of

the Council should forward their comments in the course of the ensuing week. In its new form, the report was much shorter than in previous years.

Council nominations

It was noted that those invited had accepted nomination for election to the Council for the 1961–62 Session (see April 1961 *Journal*, p. 253).

Lectures on arbitration

In response to a request from the Institute of Arbitrators, the Council agreed to support a course of lectures on arbitration being arranged by that body in London.

Society of Polish Electrical Engineers in Great Britain

The Council noted with pleasure the terms of a motion passed at the Annual General Meeting of the Society of Polish Electrical Engineers in Great Britain, conveying their appreciation of The Institution's support over the past year.

27TH APRIL 1961

Membership

The Council gave final confirmation to the election of those candidates whose names had been published with the March 1961 *Journal*, to become effective from the 1st May 1961, except for one candidate whose case was referred back to the Membership Committee. Taking these into account, the total membership at that date was 47749.

Subscriptions

The Council approved the Finance Committee's recommendation that a final notice be sent under registered cover to those members who were more than two years in arrears in the payment of their subscriptions, and that the names of those from whom there was no response be removed from the Register of Members under the provisions of Bye-law 37.

Nomination of representatives

On the recommendation of the General Purposes and the Education and Training Committees, the Council approved a number of nominations of members as representatives of The Institution on other bodies, details of which will appear in the *Journal* as usual in due course.

Visit to West Africa

The Council approved a further recommendation of the General Purposes Committee that the President and the Secretary should visit West Africa in September 1961 as part of the programme of visits to Joint Groups being carried out by the Presidents of the three institutions.

I.M.E.A. Scholarship

The Council agreed to a proposal of the Scholarships Committee that the present limitation on the total value of the annual awards made from the Incorporated Municipal Electrical Association (I.M.E.A.) Scholarship Fund be removed, since the clause to this effect in the Regulations had unnecessarily restricted the number of awards made in one year.

Annual Report

The Council authorized the issue of their Annual Report for the 1960–61 Session, as contained in the final proof copies laid on the table, for presentation at the Annual General Meeting on the 18th May 1961.

Oversea Representative for the West Indies

Approval was given to the appointment of Mr. K. W. Finch, B.SC.(ENG.), MEMBER, as Oversea Representative of the Council for the West Indies in succession to Mr. H. D. Walden, B.SC., ASSOCIATE MEMBER, who had resigned.

Electronics and Communications Section Committee

Consideration was given to a request from the Electronics and Communications Section Committee that the Section Regulations be modified in respect of the stipulated number of vice-chairmen of the Section.

The proposed modification would mean that, at discretion, there could be either one, two or three vice-chairmen in office. The Council agreed to the proposal.

SPACE-RESEARCH TELESCOPE

A FULLY steerable radio telescope is to be built at a site near Crowthorne, Berkshire, by the Ministry of Works for the Radio Research Station of the Department of Scientific and Industrial Research. It is expected to be completed and in operation towards the end of 1963, at an estimated over-all cost of £250000, including buildings, equipment and site services.

The radio telescope, which will have a parabolic aerial about 80ft in diameter, is needed by D.S.I.R.'s radio scientists for their work in the space-research programme and to study certain other aspects of radio science.

Orbital data and Earth satellites

It will have high accuracy and a faster tracking speed than the 250ft radio telescope at Jodrell Bank, an essential requirement for following Earth satellites and determining orbital data.

It will be used to receive weak signals from distant space vehicles transmitting at ultra-high frequencies.

An application of the telescope to radio astronomy will be a study of radio noise from the sun, including sudden increases in radio emission that are related to disruption in short-wave communication. Also of interest is the radio noise from planets.

The telescope will be valuable in extending investigations of the properties of the upper and lower atmosphere, which are important in both terrestrial and space communication. This feature will assume even greater significance in the next few years when satellites for communication, as well as for research purposes, are likely to come into use.

International conference on components and materials used in electronic engineering

THE Electronics and Communications and the Measurement and Control Sections are arranging an international conference on components and materials used in electronic engineering, which will be held at Savoy Place from Monday, 12th June, to Friday, 16th June 1961. In addition to the 16 technical sessions included in the programme, there will be a cocktail party at Savoy Place and a conference dinner at the Connaught Rooms.

An exhibition, associated with the conference, will include items illustrative of the material to be presented during the technical sessions.

Demands imposed on components and materials

Many recent developments in electronic engineering have been made possible by the exploitation of new components and materials.

The demands imposed on modern components and materials are becoming increasingly severe in order to comply with the onerous conditions in which a great deal of electronic equipment has to operate. Electronic computers, guided missiles, satellites, communication systems, etc. all require a high standard of electrical performance and reliability from their component parts.

The conference aims to cover recent developments in components and materials used in electronic engineering. Applications will not be included, as many of these are being dealt with in other conferences and symposia; they will be discussed only when they are essential to a description of the requirements of components or materials. Transistors, semiconductor devices and thermionic devices will not be included.

Conference programme

The programme for the conference is given below.

MONDAY, 12TH JUNE

11 a.m.	Session 1—Opening session
2.30 p.m.	Session 2—Resistors

TUESDAY, 13TH JUNE

10 a.m.	Session 3—Microwave ferrites
10.15 a.m.	Session 4—Electromechanical devices (relays, plugs, sockets, etc.)
2.15 p.m.	Session 5—Microwave ferrites
2.30 p.m.	Session 6—Electromechanical devices (magnetic recording and synchros)
5.30 p.m.	Session 7—Inductors and magnetic materials

WEDNESDAY, 14TH JUNE

10 a.m.	Session 8—Printed-wiring and potted-circuit techniques, methods of automatic assembly and methods of connection
10.15 a.m.	Session 9—Piezoelectric, ferroelectric and magnetostrictive materials and devices—I
2 p.m.	Session 10—Microminiaturization
2.15 p.m.	Session 11—Piezoelectric, ferroelectric and magnetostrictive materials and devices—II

THURSDAY, 15TH JUNE

10 a.m.	Session 12—Dielectrics
2.30 p.m.	Session 13—Capacitors—general
5.30 p.m.	Session 14—Capacitors—electrolytic

FRIDAY, 16TH JUNE

10 a.m.	Session 15—Reliability and the effects of extreme operating conditions
2.30 p.m.	Session 16—Radio-frequency connecting cables

CURRENT RESEARCH AT THE ELECTRICAL RESEARCH ASSOCIATION

THE Institution was among the founders of the E.R.A., which recently issued its 40th annual report. Over 2000 research reports have been produced by the E.R.A. since its inception. The examples of current research undertaken by the E.R.A. and given below are taken from the report of the E.R.A. Council for 1960.

Research details

The first stage in the evaluation of test methods for determining the thermal endurance of varnished-fabric insulation has been completed. Assessments have been made of the significance of weight loss, electric strength, tensile strength and extension at break.

An investigation on the use of ferroelectric materials as coupling devices has been completed. Their application is limited to low frequencies.

The fundamental research at Liverpool University on the theory of conduction in semiconductors has shown that the large increase in conductivity of germanium at field strengths near to 2V/cm and at liquid-helium temperatures, often termed 'breakdown', is connected neither with stability nor with destruction of the lattice.

A report summarizing the resistance of industrial insulating materials to surface discharges has been issued. The resistance to tracking of a poor material is not greatly increased by a substantial increase in creepage distance.

A satisfactory method of detecting ionic impurities in oil-impregnated capacitors has been developed. Plans have been made to extend this work to capacitors impregnated with penta- and tri-chlordiphenyl.

A mathematical solution for the equilibrium shapes of bubbles in an electric field has been confirmed by experiment. The solution was derived to explain some of the phenomena in the breakdown of highly stressed impregnated dielectrics.

Direct measurement has confirmed that the drop in intrinsic electric strength of polythene with increase in temperature is due to compression under electrostatic forces.

By rigorous attention to cleanliness and purity, aluminium oxide films on a dielectric have been made to withstand field strengths of 400V(d.c.)/μm for long periods. Plastic-foil capacitors have been successfully impregnated after embossing the plastic with a corrugated pattern about 1μm deep.

Artificial surge tests on a fully insulated 11kV wooden-pole line have shown that the rate of attenuation was slow enough to explain the simultaneous operation of fuses over long distances of line.

The articles in this regular monthly feature are based on current papers read at Institution meetings. They are written by the authors of the papers, who have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the articles bring out the main points and conclusions of the papers, their contents are not necessarily confined to the subject-matter of the original papers

FORMAL STUDY IN POSTGRADUATE TRAINING

A paper (3539) 'The place of formal study in the postgraduate training of an electrical engineer' by N. N. Hancock, M.Sc.Tech., and P. L. Taylor, M.A., Associate Members, was read at an Ordinary Meeting at Savoy Place on the 2nd March 1961 (see p. 334). This short article is based on the paper, which was published individually in February 1961 and will be republished in Part A of the Proceedings. Mr. Hancock is at the Manchester College of Science and Technology, and Mr. Taylor is with Associated Electrical Industries (Manchester) Ltd.

THE continuing explosive growth of human knowledge in the field of electrical engineering poses a great problem to those who are responsible for the education and training of young men, and also to the young men themselves. It is widely held that the usual undergraduate course of three years' duration is now inadequate and that some further period of formal study is required. The paper reviews some of the problems involved in the organization of postgraduate courses and is based on the authors' experience. A course with which the authors are concerned is briefly described.

The paper is not exhaustive: it concentrates on the needs of men who will be entering the research and development activities of industry, for whom there seems to be a need for regular courses of a theoretical and analytical type which should be available annually. Short, *ad hoc* courses of a more technological and factual type are not considered.

Adequacy of undergraduate courses

But first, are three-year undergraduate courses really inadequate? Would not the problem be solved by increasing the length of undergraduate courses to four years? The authors argue that this is undesirable. The first concern of an undergraduate course should be to develop and train a man's mind, to inculcate habits of critical inquiry, of careful observation and of logical deduction, and to develop in him the ability to learn for himself. It will convey facts in the course of such training, but at this stage the facts are relatively less important. For all this, three years would seem to be adequate.

The object of a postgraduate course should be different: factual information becomes important in itself, and it should help the student in his transition to the life of a productive, creative engineer. The modes of thought appropriate to this are an extension of those appropriate to undergraduate work: creative work is not only deductive, but also inductive; not only analytic, but also synthetic. The danger is that, if a fourth year of study follows immediately on the previous three, it may come to be regarded merely as an extension in time whereas it should be an extension in nature.

If a student is to appreciate this difference, it is desirable that he should have an intervening period, following graduation, in which to be exposed to practical engineering and to widen his experience. Another reason for deferring postgraduate study is that every year at that stage in a man's development brings a marked increase in maturity, as a result of which further study becomes more effective and more valuable. It is not unknown that men who have achieved only ordinary degrees have, under the stimulus of exposure to practical engineering for the first time, found their feet and profited greatly from subsequent postgraduate study.

Organization and length of postgraduate courses

Postgraduate courses should be organized by, and held at, the universities. There are several reasons for this. Admittedly, a large industrial organization could run the courses itself for its own employees, but this would not serve the needs of the smaller firms. The basic facilities, such as a library and laboratories, are already available at a university. Participation in lecturing at a postgraduate level should be stimulating to the staff. The courses would be available to industry as a whole.

However, it is all the more important that the universities should seek and accept the advice and help of industry. The most important industrial help they will need is part-time lecturers from industry, whom industry must be prepared to release and whom the universities should welcome, with some sort of academic recognition, for the sense of practical reality they bring to the class-room and to informal discussions with the staff.

How long should postgraduate courses last? The paper suggests that current experiments with one-year courses, run on the usual pattern of three terms, will not at present meet the major need. It is argued that the economic pressures on young men who join industry immediately after graduation are such that few of them will wish to return to university for a whole year; the danger is that full-sessional courses may tend to attract men to stay on immediately after graduation, with the educational disadvantages mentioned above. Industrial opinion favours shorter, more intensive courses.

Papers read (continued)

Part-time or full-time courses?

The paper discusses the advantages and disadvantages of part-time courses of, say, one day per week extending over a session and full-time courses lasting a few weeks, and concludes that on balance the latter are preferable. This conclusion is based in part on actual experience with a course which started as a part-time one and was changed to a full-time one lasting eight weeks.

The main advantages of a full-time course are that students can come from greater distances than with the one-day course; experience seems to show that students prefer, and work better with, a period of uninterrupted study; and work in industry is less disorganized than with weekly absences. The main disadvantage is the peak load on the academic staff, and here industry must be prepared to help.

Description of courses

The paper ends with a description of courses that form part of an industrial two-year apprenticeship. The first year's work, organized by the firm concerned, comprises lectures and tutorial classes in mathematics and engineering topics. These serve the purpose, among others, of making possible an equitable selection of the men to attend the second-year part of the course, which is organized by the Manchester College of Science and Technology. 331.86 : 621.3

Depreciation of engineering plant

This short article is based on a Supply Section paper (3366) 'A general theory of depreciation of engineering plant' by D. Rudd, B.Sc.(Eng.), A.M.I.Mech.E., Associate Member. The paper was published individually in November 1960 and will be republished in Part A of the Proceedings. It was read at Savoy Place on the 15th February 1961 *(see p. 328)*.

THERE are three kinds of people who are professionally concerned with the depreciation of engineering plant, namely engineers, accountants and income-tax inspectors.

Three methods

The engineer's concern is primarily with estimating the total annual cost of a project, including interest on its capital cost and provision for depreciation. He usually wants to compare one scheme with another, and so, in order to make the comparison as simple as possible, he uses the so-called 'annuity' method of providing for depreciation, in which the capital charge—that is interest plus provision for depreciation—is the same in every year. The effect of this artifice is that the provision for depreciation increases year by year as the interest on the outstanding capital cost decreases throughout the economic life of the project.

If and when the project is constructed and goes into service as an engineering plant, its finances will probably pass into the hands of an accountant. Although he may accept the engineer's estimate of the life of the plant, the accountant will nevertheless usually adopt a different method of providing for depreciation. His concern is with the written-down value of the plant at any instant, and he will write it down by a fixed amount every year. This method is known as the 'straight-line' method.

When the affairs of the body which owns the plant come to be assessed for income-tax, the tax inspector will use a third method. In the first year he will make an initial allowance; this is at present 20% of the capital cost, but it varies from time to time. Apart from this, the rule is to allow the plant to be written down in every year by a constant percentage of its value at the beginning of that year, and then to allow it to be finally written off in the year when it is scrapped or otherwise disposed of, which may not be until some time after the end of its economic life as assessed by the engineer and the accountant. This is known as the 'reducing-balance' method.

There are thus three conventional methods of providing for depreciation, all of them arbitrary and producing different assessments of annual cost, as illustrated in Fig. 1. This situation tends to vitiate any decision which relies on such assessment, and it is therefore pertinent to inquire whether a solution can be found which will satisfy the legitimate requirements of all three parties and enable the true annual cost of an engineering plant to be ascertained.

The general theory

One of the cornerstones of engineering is the principle that the total annual cost in every year should be no greater than the cost of the cheapest alternative method of providing the same service. Accordingly, the general theory of depreciation is that the capital charge in every year should be such as to achieve this object. Starting from this theory, it is possible to proceed step by step to show that both the economic life of an individual engineering plant and its total annual cost in every year depend on five factors:

(i) *The rate of physical deterioration* of the plant
(ii) *The rate of technological advance* in the industry concerned
(iii) *The capital cost* of the plant
(iv) *The rate of interest*
(v) *The load factor*, or other appropriate measure of the use made of the plant.

If these factors are known or can be estimated, the economic life and the successive annual provisions for

depreciation can be calculated by means of mathematical formulae.

In practice, (iii), (iv) and (v) have to be estimated whatever method of providing for depreciation is used, and there is not much difficulty about (i), except for a completely new kind of plant which is, in any case, always a speculation. The most difficult factor to estimate is undoubtedly (ii)—though even here the problem is no greater than estimating the life of the plant in order to use one of the conventional methods—but the fact that (ii) applies to the whole industry can sometimes lead to a further development of the general theory, which in turn provides the basis for estimating this factor.

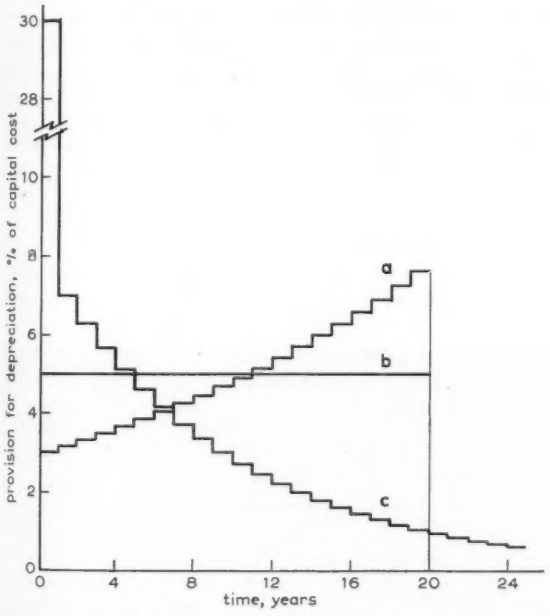
Integrated industry

For this development to be possible, the industry concerned must be integrated (the nationalized fuel industries are obvious examples) and must have a more or less continuous programme of investment. In such an industry it is possible to co-ordinate the capital charges on all the plants in operation, so that, when their total annual costs in a given year are compared with one another, the requirement of the general theory is complied with.

For instance, the capital charges on the power stations in Great Britain can be co-ordinated by a differential equation, derived from the theory. It is then found that the total annual costs of the stations (excluding only the obsolete stations), when plotted against their annual outputs, lie on a smooth curve, as illustrated in Fig. 2. For the year in question, the curve is approximately rectilinear, having the form:

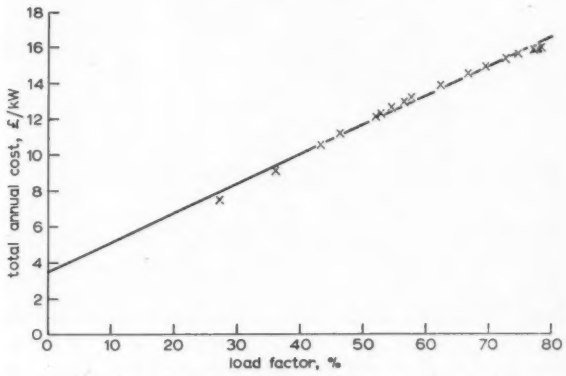
Total annual cost = £3 10s./kW × capacity of station in kilowatts + 0·447d./kWh × annual output in kilowatt-hours

What may seem surprising to supply engineers is not that such a formula is valid for an individual station but that the same coefficients apply to every non-obsolete station in that year, although the stations differ widely in age, capacity, capital cost, thermal efficiency and works cost. The two coefficients, £3 10s./kW and 0·447d./kWh, are therefore representative of the whole industry. As the technology of generation improves, they must decrease in real terms; but because existing generating stations can be replaced only gradually, the rate of decrease will be both limited and largely predictable. Such predictions would provide the necessary data for assessing the economic merits of any new individual scheme for generating electricity and enable its economic life and successive annual provisions for depreciation to be estimated.



1 *Comparison of conventional methods of providing for depreciation*

a annuity method
economic life = 20 years
rate of interest = 5% p.a.
b straight-line method
economic life = 20 years
c reducing-balance method
initial allowance = 20%
annual allowance = 10%



2 *Correlation of total annual costs of generating stations*

× × × × representative stations
——— empirical relation

The data relate to Great Britain in 1948–49, but, though realistic they are not authentic

Monetary inflation

No discussion of depreciation would be complete without some mention of the phenomenon of monetary inflation. The conventional methods of providing for depreciation are commonly regarded as unsatisfactory in the event of rapid

Papers read (continued)

or persistent inflation during the life of the plant. It can be shown, however, that the major effect of inflation (or deflation) is on the real rate of interest rather than on the real rate of depreciation. Provided that a clear distinction is made between real and monetary values, the successive real provisions for depreciation (from which the monetary provisions can be calculated without difficulty) are affected only to the comparatively minor extent that the rate of interest itself affects the economic life of the plant. Furthermore, it becomes clear that the total provision for depreciation over the life of the plant should amount to its original or 'historic' cost, in accordance with present practice, and not its replacement cost.

621.3 : 657.372.3

Electrical requirements of general-cargo docks

A brief account based on a Utilization Section paper (3365) entitled 'Some notes on the electrical requirements of general-cargo docks' by E. R. Radway, M.I.Mech.E., Member. The paper was published individually in December 1960 and will be republished in Part A of the Proceedings. It was read before the Section on the 9th February 1961 at Savoy Place (see p. 330). The author is with the British Transport Commission, South Wales Docks.

HANDLING the £8000 million worth of Britain's imports and exports in and out of ships is an essential service which, although adding nothing to the value of the goods, affects the cost of living of everyone in the country and also the ability to quote competitively in the world's markets.

Carrying out this task efficiently necessitates dock systems providing deep-water anchorages for shipping, safe from the stress of weather, and forming rail- and road-heads equipped with modern aids to materials handling, transit sheds, warehouses and adequate power supplies (Fig. 1).

In order to give this service to the community, the dock organizations have become, generally speaking, port authority trusts, civic-controlled port authorities or the Docks Division of the British Transport Commission. Where such docks exist close to one another, they are grouped into port systems, giving the advantages of stronger financial structure, plant standardization, and flexibility to meet peak demands by transfer of mobile plant, and allowing a professional staff to be engaged continuously on development and maintenance work.

1 *Swansea docks*

Power supplies

Power supplies for dock systems were originally provided and maintained by the mechanical engineer, who operated steam-powered impounding and dry-dock dewatering pumps, and also steam-powered hydraulic-pressure pumping stations to provide hydraulic pressure for the lock-gate machinery and the hydraulically-operated mechanical-handling plant. Electrical generating plant performed the minor role of supply for lighting and a few small power requirements.

Electrical development over the past 25 years has radically altered this concept, and the mechanical and electrical utilization engineer is needed to appreciate and apply the potential of both fields. Private generating plant is uneconomic, and the dock authority makes use of the public supply of the Area Board. It receives and distributes at 6·6 or 11 kV, acts as a supply authority to the many businesses sited on the extensive dock estates, and, in addition, utilizes the electric power for the cranes, pumping stations and other services required for dock operations.

Hydraulic power and impounding

Although hydraulic power generated by suitably sited pumping stations is still used for such plant as lock gates and coal hoists, steam operation of the pumps has given way to high-speed electrical operation, reducing considerably the production costs. This trend continues in the elimination of

hydraulic plant fed by pipe rings in favour of electrical operation, and in the application of the direct oil-hydraulic system.

Impounding pumps of up to 6 million g.p.h. capacity, using heads of about 20ft, are required for impounded docks, and these are now electrically operated, often by direct-on-line-started motors of vertical construction. Such pumps should be sited in the same station as the hydraulic-pressure pumps, in order to keep manning and building costs to a minimum.

Fig. 2a illustrates a combined hydraulic and impounding station using a building originally occupied by steam plant, and having the site limitations of existing suction and delivery piping; and Fig. 2b shows a newly constructed station of advanced design.

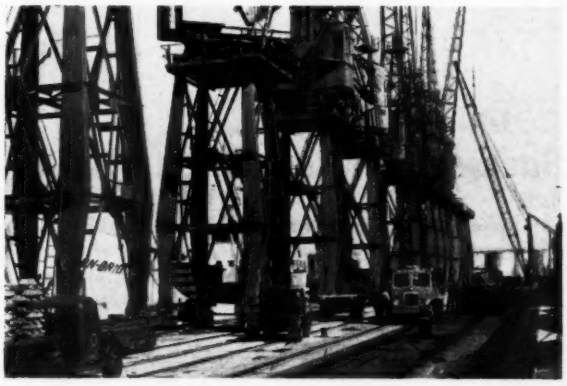
Cargo-handling plant

The general-cargo mechanical-handling sequence requires the operation, within the transit sheds, of mobile cranes, sack-piling conveyors, stillage trucks, and fork-lift trucks, which feed or receive from the quayside cranes.

The quayside cranes (Fig. 3) are of the electrically-operated balanced-jib level-luffing type, usually of 3 or 6 tons' capacity throughout the luffing range of about 20ft minimum to 80ft maximum radius, but there is a noticeable demand for larger general-cargo cranes of about 7½ tons capacity.

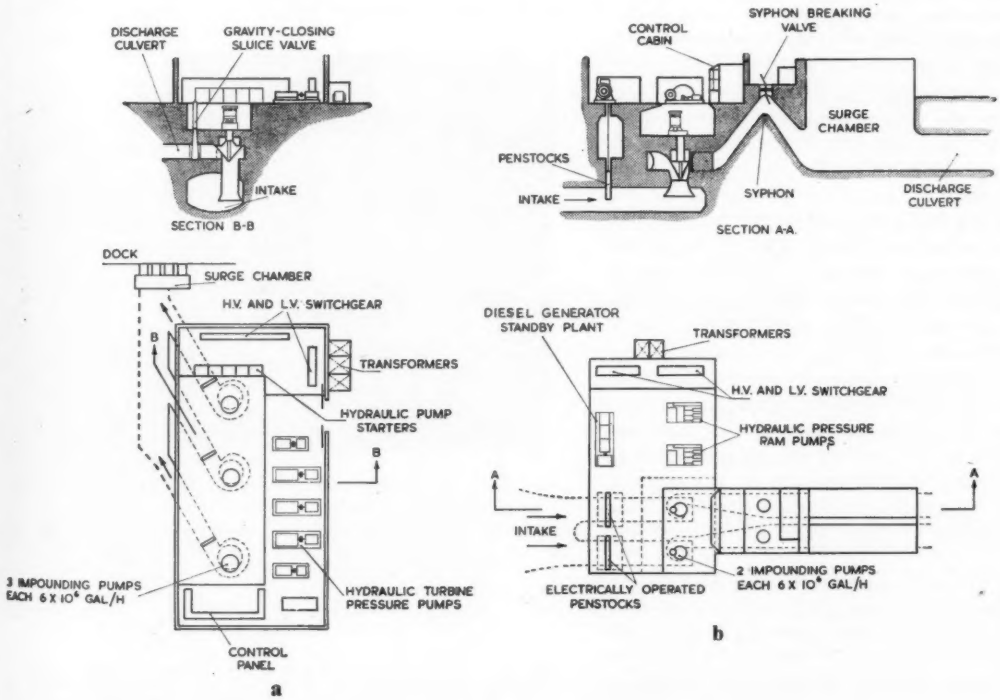
For handling bulk cargo, 10ton-capacity four-line grabbing cranes are used; but where site conditions permit the ores to be transmitted by conveyor direct to the user, the 'kangaroo' version of these cranes is often favoured.

Because of its distribution advantages, alternating current



3 *Some of the new 3|6ton electric cranes at Newport docks*

is in general use for the cranes, which are fed by flexible cables from plug boxes on the quayside. It is generally suitable for the luffing, slewing and travelling motions, but the



2 *Typical hydraulic and impounding pumping stations*
a Station converted from steam to electric operation
b Station of new design

Papers read (continued)

pressure for a quicker turn-round of shipping, requiring cranes with high hoisting and lowering speeds, has made designers overcomplicate a.c. control systems in an attempt to give characteristics similar to those available with direct current. The time has arrived when there must be a recasting of lines of thought with a view to simplification.

621.316.17 : 629.12.018

Back-scatter sounding in h.f. broadcast services

An Electronics and Communications Section paper (3506) 'An investigation of the usefulness of back-scatter sounding in the operation of h.f. broadcast services' by E. D. R. Shearman, B.Sc., Associate Member, was read before the Section on the 6th March 1961 at Savoy Place (see p. 330). This short article is based on the paper, which was published individually in February 1961 and will be republished in Part B of the Proceedings. The author is at the Radio Research Station, Ditton Park, Slough, Bucks.

When operating an h.f. broadcast service to cover a particular region of the Earth's surface, the engineer must choose the transmission frequencies and the directional characteristics of the aerials so that the desired area is illuminated most effectively with radio waves.

The choice of the azimuthal beamwidth of the aerial is usually a simple geometrical problem, but the choice of the vertical-radiation pattern and the best transmission frequency requires a knowledge of the way in which the height and electron density in the ionospheric layers vary along the transmission path for the time and season of interest. The average layer-configuration can be obtained from maps of predicted ionospheric characteristics, normally issued from three to six months ahead.

Such predictions are for average conditions only. Since not enough is yet known about the way in which the pattern of ionization over the world changes from day to day in response to solar flare and sunspot activity, the ensuing changes in radio propagation along a particular path are very difficult to assess.

Measurements of energy distribution

Measurements of the distribution of energy over the Earth actually achieved by a transmission are clearly desirable. These can be provided by listeners' reports, but there is necessarily a delay before the reports are received, and the observations are limited to the specific localities of the observers.

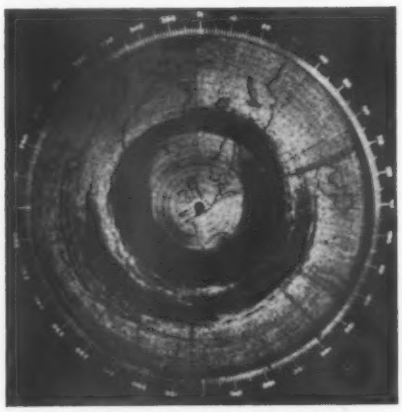
The paper describes an experimental investigation of the usefulness of a radar technique ('ground back-scatter sounding') for observing the distribution of energy over a broadcast-service area.

In back-scatter sounding, pulses of radio waves are radiated from a directional aerial, and the ranges of the illuminated zones of the Earth are determined by measuring the time delay of the returning echoes from irregularities on the Earth's surface. These zones have an azimuthal extent governed by the beamwidth of the transmitting aerial and lie beyond the skip distance determined by the transmitted frequency and the prevailing ionization and height of the reflecting layer.

Fig. 1 shows the illuminated zones observed at 17 Mc/s during earlier experiments at the Radio Research Station at Slough with an all-round-looking rotating aerial and a back-scatter plan-position indicator. The dark areas represent the zones, the positions of which can be identified from the superimposed map.

Experimental transmissions

Two series of tests were carried out, in February and in March 1957. In both tests, 1 ms pulses of 50 kW peak power were radiated southwards from the British Broadcasting Corporation's oversea broadcasting station at Rampisham, Dorset, and received at Slough. Comparison transmissions were made from Slough.



1 *Zones of the Earth illuminated by a 17 Mc/s transmission, 1640 G.M.T., 7th October 1954*

The dark areas represent the parts of the North Atlantic and Europe from which back-scattered echoes were being received by a 17 Mc/s rotating-aerial radar equipment

The February transmissions, which were at a frequency of 21 Mc/s, were made in daylight. The ionosphere at this time

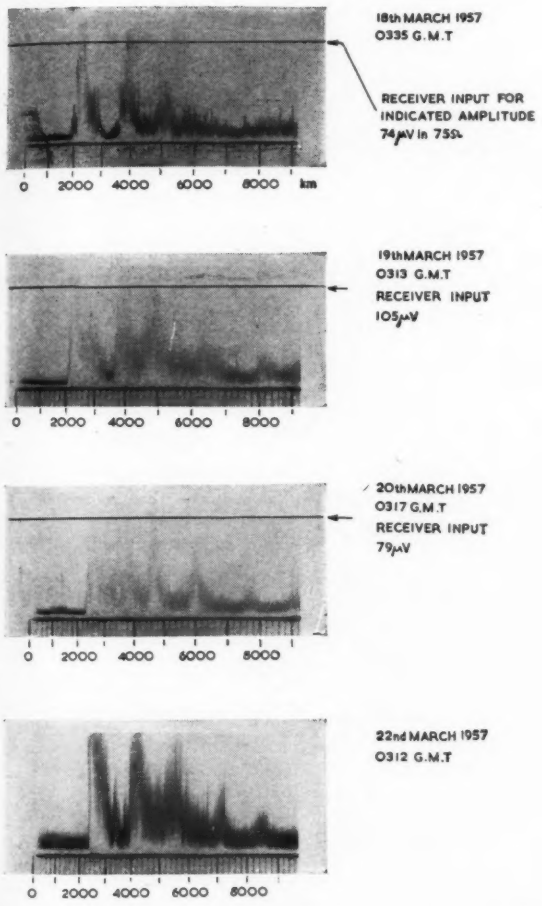
was very stable, and the back-scatter echo-patterns seen on a normal cathode-ray-tube range/amplitude display were similar from day to day.

The patterns showed clearly the effect of the vertical patterns of the aerials. For example, the shortest-range echoes received, i.e. those from just beyond the skip distance, were weak, although these would be the strongest returns for an aerial radiating uniformly at all vertical angles.

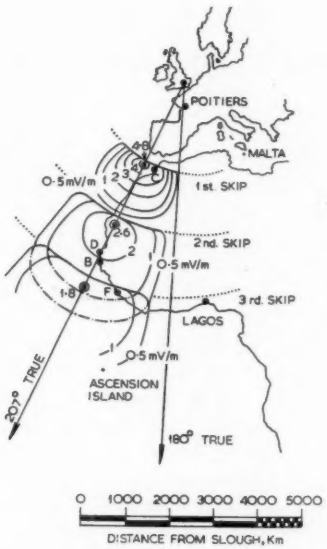
The main features of the pattern shapes, calculated by the radar equation from simultaneously measured ionospheric parameters along the path (when these became known), agreed very closely with those observed. Differences seen between the echo-patterns for the Rampisham and for the Slough transmitter agreed with those calculated for the different aerial vertical-radiation patterns.

This observation suggested a practical use for the technique. Transmissions might be made on various aerial systems, and the one giving the highest echo strength from a desired range chosen for operational use.

The March transmissions were at 15 Mc/s at 0300 G.M.T. The observed echo-patterns are shown in Fig. 2, in which successive echo groups can be identified. These correspond to back-scatter from the ground-reflection areas for propagation by up to five hops. Large variations can be seen in the echo-patterns observed on successive nights.



2 *Back-scatter echo-patterns, Slough transmitter, 18th–22nd March 1957*



3 *Field strength set up at ground by ionospherically-reflected radiation from rhombic aerial at Slough*

From 0300 G.M.T. March predictions
—·—·— Contours for the 2-hop field at locations for which the 3-hop field is stronger
F Freetown B Bathurst D Dakar C Casablanca

Fig. 3 shows the energy distribution calculated from vertical ionospheric soundings along the path on the 19th March. The features of the echo-pattern calculated for this and the other nights are in good agreement with the observed pattern.

Listeners' reports

Confirmation of the accuracy of the back-scatter returns as a guide to the distribution of energy along the great circle was obtained from listeners' reports. Observers at Malta and at Lagos, critical ranges for 1-hop and 3-hop propagation respectively, reported field-strength and pulse patterns in accord with those deduced from the echo-patterns.

The practical implication of these results is that a good guide to the coverage of an h.f. transmission, even to long distances, can be obtained by back-scatter observations.

621.396.97 : 621.391.812.63

In this monthly section are summaries of papers published in the *Proceedings* of The Institution which have not been read at Institution meetings. They are included primarily for reference. Reprints, price 2s., become available about two months after publication

B.B.C. sound broadcasting 1939–60

A summary of a Review of Progress (paper 3560) with the above title by E. L. E. Pawley, O.B.E., M.Sc.(Eng.), Member. The paper is published this month in Part B of the Proceedings. A companion paper (3588) 'B.B.C. television 1939–60' by the same author will be published later in Part B of the Proceedings. The author is with the British Broadcasting Corporation.

THIS review discusses mainly the work of the B.B.C., although reference is made where appropriate to other major developments in this field both at home and abroad, and tribute is paid to the achievements of the industry and to the co-operation of the British Post Office.

The review deals first with the wartime activities of the B.B.C., including the great expansion of the European and Overseas Services. It describes the establishment of the national network of v.h.f. f.m. transmitters and the effect of the shortage of frequencies on these and other developments. The technique of operating transmitters in synchronized groups in order to obtain the maximum coverage with the limited number of frequencies available was introduced first on medium waves and has been extended to short-wave transmitters at different sites.

Transmitting stations

The number, power and efficiency of transmitting stations have steadily increased; improvements in the design of high-power transmitters have included the use of air-cooled valves (and more recently of vapour-cooled valves), the development of valves with thoriated filaments, and the use of mercury-arc rectifiers instead of motor-generators for h.t. supply. Improved anti-fading mast radiators have been designed for medium waves and highly directional aerials for long-distance short-wave transmissions. Increased knowledge of the propagation of radio waves has led to greater efficiency in their use, particularly in the short-wave bands.

Precision drives for transmitters have been developed giving a higher order of accuracy of the carrier frequency with simpler and cheaper equipment. Both low-power and high-power transmitters have been designed for unattended operation, using automatic or remotely controlled switching, and automatic equipment has been introduced for monitoring these transmitters and the line links between B.B.C. centres. Low-power transmitters have been developed which receive v.h.f. transmissions and relay them after translating them to a different frequency in the same band without demodulation.

Studio and outside-broadcast equipment

Improved knowledge of studio acoustics and developments in the design of microphones have led to improved quality of sound, of which full advantage is taken when the programmes are received on v.h.f. rather than on long and medium wavelengths. Studio and control-room equipment has been reduced in size, and the use of uniselector switching has improved the operational flexibility of the system. Switching between successive programme items has been removed from main control rooms to continuity suites, where close liaison between the technical operator and the continuity announcer ensures the smooth running of the programme and prompt action in an emergency. There has also been a steady improvement in the design of high-quality loudspeakers for monitoring purposes.

Equipment for outside broadcasts has been made lighter and smaller by the use of transistors, and a type which can be operated by the speaker without an engineer in attendance has been developed for simple commentaries. Radio microphones have proved useful where a trailing lead would be an encumbrance. There have been substantial developments in the design of measuring apparatus, both for laboratory and service use, including frequency-measuring, monitoring and automatic line-testing equipment.

The review also traces advances in sound recording, where magnetic tape has to a large extent replaced cellulose-coated discs.

Domestic receivers

Major improvements in the design of domestic receivers by the industry have included the use of the a.c.–d.c. technique, of miniature valves and of transistors and the development of v.h.f. f.m. receivers and of radio receivers for cars.

Engineering training

Although a saving in manpower has been achieved by the new switching and monitoring techniques described, the problem of making good losses of trained staff due to retirements and resignations and of meeting new demands has remained a serious one. The B.B.C.'s Engineering Training Department has therefore been established to train recruits and to give more specialized training to established staff.

International co-operation

Before and after the Second World War, international co-operation led to the wide diffusion of technical knowledge and to improvements in the international exchange of programmes. A notable advance in this latter field was the opening in 1956 of the transatlantic telephone cable, which makes it possible to combine two telephone circuits to provide a high-quality circuit for the transmission of broadcast programmes. The number of sound programmes exchanged with other countries increased 15-fold between 1939 and 1960.

The review includes tables and maps showing the growth

of the B.B.C.'s engineering facilities and the increase in the coverage of its programmes during the period. 621.396.712

Reduction of the exciting current of inductive devices

A summary of a Measurement and Control Section paper (3519) 'A circuit for reducing the exciting current of inductive devices' by D. L. H. Gibbings, B.E., B.Sc., Ph.D. The paper is published this month in Part B of the Proceedings. The author is in the Division of Electrotechnology, National Standards Laboratory, Commonwealth Scientific and Industrial Research Organization, Australia.

A negative-feedback device is described in which the greater part of the exciting current necessary to energize a magnetic core is supplied by an amplifier, so that windings on the core present a much higher impedance than with the core material alone. An improvement of more than 100 times has been achieved at 50 c/s. To the external circuit the device appears as a composite core, which may be wound in any desired manner.

An investigation is made of the effect of using such a core on the voltage and current ratios of a 2-winding transformer, and a proposal is made for using a shielding technique to achieve high precision. 621.314.222 : 621.372.523

Ionospheric forward scattering

A summary of an Electronics and Communications Section paper (3508) 'Studies of ionospheric forward scattering using measurements of energy distribution in azimuth' by W. C. Bain, M.A., B.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the Radio Research Station, Ditton Park, Slough, Bucks.

Measurements of phase and amplitude were carried out on signals of 37 Mc/s received from a transmitter at Gibraltar. The receiving sites were at Slough and at Castlemartin, Wales, each about 1740 km from Gibraltar, and were equipped with pairs of aerials whose spacing could be varied from λ to 10λ.

The results were not consistent with the idea that the forward-scattered signal was due to the combination of many randomly-phased radio waves. Frequently one signal appeared to be dominant, as might be expected if reflections from meteor trails formed an important part of the resultant signal. The calculation of an azimuth power distribution on the basis of phase measurement with different aerial spacings then becomes of uncertain validity.

Some results obtained in this way are presented, but reliance is placed mainly on work with a small, fixed aerial spacing. This shows a marked diurnal variation of mean bearing; at Slough for most of the year it is on average 7° W. of the Gibraltar bearing by night but 0° W. by day. Comparison with observations at Castlemartin suggests that the scattering process is due almost entirely to meteor reflections by night but that during the day there is also present a component due to turbulent scattering which contributes rather more than half the total energy. 621.391.812.63

Delayed signals on an ionospheric forward-scatter circuit

A summary of an Electronics and Communications Section paper (3509) 'Directional observations on delayed signals on an ionospheric forward-scatter circuit' by W. C. Bain, M.A., B.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the Radio Research Station, Ditton Park, Slough, Bucks.

A study was made of delayed signals reaching Slough from a transmitter at Gibraltar on 37 Mc/s in the winter of 1956–57. The mean bearing of the first signal to arrive after that due to ionospheric forward-scatter was found to vary between 250° and 290° during the day; the spread of energy in bearing is also considered. It is shown that the radiation from the transmitter aerial must be stronger to the west than to the south. Results for the second delayed signal are also given. Round-the-world echoes were occasionally observed, but these did not arrive from the direction of the great circle containing Gibraltar and Slough. 621.391.812.63

Band compression in television transmissions

A summary of an Electronics and Communications Section paper (3507) 'Television band compression by contour interpolation' by Prof. D. Gabor, Dr.-Ing., F.R.S., F.Inst.P., Member, and P. C. J. Hill, Ph.D. The paper is published this month in Part B of the Proceedings. Prof. Gabor is Professor of Applied Electron Physics, and Dr. Hill was formerly in the Department of Electrical Engineering, Imperial College of Science and Technology, University of London. Dr. Hill is now at the B.B.C. Research Station.

Band saving in television transmissions can be achieved by utilizing redundancies in single lines, between lines, between fields and between frames. The method of contour interpolation exploits the last two. It is based on the facts that:

(i) Field and frame frequencies in conventional television transmission had to be chosen with a view to reducing flicker rather than conveying more information
(ii) The eye fixes mainly on contours, which are usually the edges of objects
(iii) These contours are usually smooth enough to allow interpolation over two line spacings
(iv) Changes from one picture to the next come about mostly by the horizontal motion of objects which are sufficiently uniform to allow interpolation over at least two frame intervals.

There is almost no loss in information or picture quality if the interlaced frame is suppressed in the transmission and

reconstructed in the receiver by interpolation between the lines of the transmitted field, and there is not much loss if only one field in four is transmitted. In the method of contour interpolation, the reconstructed edges are as sharp as the originals and appear in their correct positions, i.e. in the positions that they would occupy if the edges were straight in small sections and if their motion were uniform for short times.

The waveband gain can be estimated at 4 : 1 without appreciable deterioration in picture quality and 8 : 1 if some deterioration is allowed with rapid and vertical motions. In combination with other methods which utilize redundancies in single lines and which by themselves achieve a gain of 3 : 1, total compression ratios of 12 : 1 to 24 : 1 appear feasible.

The principle was realized and tested in a photo-mechanical model working at low speeds. Electronic realizations are proposed and discussed. 621.397.331 : 621.391

Radio interference from ignition systems

A summary of an Electronics and Communications Section paper (3550) with the above title by A. H. Ball, Member, and W. Nethercot, M.A., B.Sc., F.Inst.P. The paper is published this month in Part B of the Proceedings. Mr. Ball is with Joseph Lucas (Electrical) Ltd., and Mr. Nethercot is at the Electrical Research Association Laboratory.

THE authors record the results of some tests made in the United States to compare results obtained with American, German and British radio-interference-measuring sets when measuring the interference radiated by the ignition systems of motor vehicles. The tests show the close agreement between the results obtained when using the various national measuring sets and confirm the reliability and consistency of measuring equipment conforming to the specification of the International Committee on Radio Interference (C.I.S.P.R.). An attempt is made to establish a relation between the results of peak and quasi-peak measurements.

The authors also tabulate and discuss the test conditions specified in the various countries and quote the limits of ignition interference recommended or statutory in the countries concerned. A direct comparison of these limits, which is made possible by these measurements, suggests that the existing and proposed requirements of other countries are more onerous than those of the United Kingdom.

621.391.823 : 621.43.04

Probabilities of interference with mobile field radio

A summary of an Electronics and Communications Section paper (3472) 'Probabilities of interference with mobile field radio derived from a field-strength survey at 59 Mc/s' by Maj. D. R. W. Thomas, M.B.E., Royal Signals, Associate Member. The paper is published this month in Part B of the Proceedings. The author is with the 28th Signal Regiment.

AN account is given of an experimental investigation of common- and immediately-adjacent-channel interference areas for mobile-radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. The variation of field strength with distance is shown to be in close accord with calculation. Particular attention has been paid to investigating the distribution of field strength at each distance, which is shown to approximate closely to log-normal.

It is also established that the variance of these log-normal distributions may be considered to have a single value for each type of country, irrespective of range. Protection ratios acceptable for satisfactory operation are determined from experimental observation of common- and adjacent-channel interference. The derived data are used to determine probabilities of interference and are presented graphically for practical use. 621.391.82 : 621.396.6

THE JOURNAL DIGEST | MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monograph as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Wide-band coupling systems between a waveguide and a transmission line

Monograph 442E

B. ROGAL, B.SC.(ENG.), *and* PROF. A. L. CULLEN, O.B.E., PH.D.

THE authors describe a wide-band microwave system suitable for coupling power between a coaxial line and a waveguide or between two waveguides. Such a system can be applied to normal matched transmission as well as, for example, to coupling power between a coaxial klystron cavity and a waveguide. An appreciable improvement in performance over other schemes results in an almost constant power transfer over a bandwidth in the region of 25%. A practical example of the system in X-band is described.

The conductivity of oxide cathodes. Part 10—Spontaneous generation of negative ions

Monograph 443E

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.)

THE experimental work described here proves that a barium-strontium-oxide matrix is thermally unstable at 1020°K and continuously generates negative ions of oxygen in its hollow pore system. The barium oxide component of the matrix is essentially stable, and the strontium oxide component is the oxygen-ion generator. The action is a fundamental one and proceeds at constant and unalterable rate. Factors determining the equilibrium concentration of free oxygen ions in the pores are examined and

described. One conclusion reached is that donor concentration of a thermally activated barium-strontium-oxide matrix is almost wholly strontium metal.

The conductivity of oxide cathodes. Part 11—Thermal stability of the alkaline-earth oxides

Monograph 444E

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* H. BATEY

THE three common alkaline-earth oxides are examined for thermal stability at 1200°C. In an experimental arrangement involving a massive evaporation from a platinum substrate, it is shown that barium oxide is removed in the form of unchanged molecules while strontium and calcium oxides leave the substrate in elemental form as metal and oxygen. It is concluded that the dissociation is a thermal one and not concerned with the nature of the substrate.

Transitional electrical units

Monograph 445

L. YOUNG, DR.ENG., M.A., M.S.

THE author considers the six metric systems of electrical units in common use. The equations of the systems differ by constants involving 4π and (approximately) 3×10^{10}. Although this is well understood and accepted, difficulties sometimes arise when a comparison is made between the units or quantities of different systems. The author endeavours to show that these difficulties are largely semantic, and that they can be overcome with 'transitional electrical units' by converting a given unit into its transitional counterpart and thence into the unit of the desired system.

Internal waveform distortion in silicon-iron laminations for magnetization at 50c/s

Monograph 446M

PROF. F. BRAILSFORD, PH.D., *and* J. M. BURGESS, B.SC.(ENG.)

THE internal distribution of magnetic flux and eddy currents to be expected in a homogeneous magnetic lamination having a sinusoidal total flux has been investigated experimentally using an analogue. It is concluded that the anomalous loss in laminations found to occur in practice cannot be accounted for by waveform distortions within the lamination.

The motion of cold-cathode arcs in magnetic fields

Monograph 447S

A. E. GUILE, PH.D., B.SC.(ENG.), T. J. LEWIS, PH.D., M.SC., B.SC.(ENG.), *and* P. E. SECKER, PH.D., B.SC.(ENG.)

THE authors first discuss the way in which theories concerning the motion of cold-cathode arcs when acted on by a magnetic field have ranged from proposing cathode-fall mechanisms for retrograde motion to column processes for forward motion. A very recent mechanism proposed by Ecker for retrograde motion is examined and found to be capable of extension to higher pressures where forward motion occurs.

Previously published experimental results for forward motion are viewed in the light of this mechanism, which is found to be consistent with them, and some features which had hitherto been anomalous may now be explained. There emerges a unified model for the cathode spot and fall region, which appears to be valid for both forward and retrograde movements of the arc. It is suggested that this provides a vital step in the approach to the development of certain devices in which arc discharges take place.

Frequency-response analysis of displacement governing in synchronous power systems

Monograph 448S

P. A. W. WALKER, B.ENG., *and* A. S. ALDRED, M.SC., PH.D.

THE authors describe the application of the frequency-response concept to the analysis of displacement governing in a synchronous-machine system. The governor loop is shown to combine with the basic closed-loop pattern of the generator and to modify only the feedback element in the original basic loop. The analysis is used to compare stability boundaries for different governor conditions, these boundaries being derived by the application of the Nyquist stability criterion. The results obtained by this method, although based on small-displacement theory, were found to be in agreement with those obtained from a power-system simulator.

The effects of phase lags, arising in the steam header of the turbine and the servomechanism operating the throttle valve, on the stability of the system are considered together with that of a second-derivative stabilizer. An examination is also made of the damping in the system, as this provides a useful appraisement when comparing the relative stability of different configurations in the governor loop.

THE JOURNAL DIGEST | IN THE PROCEEDINGS

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in CAPITALS is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (APRIL 1961)

See the Journal for April 1961, p. 238

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING MAY (1961)

W. C. BAIN, M.A., B.SC., PH.D. PAPER 3508E **Studies of ionospheric forward scattering using measurements of energy distribution in azimuth** *May 1961*

W. C. BAIN, M.A., B.SC., PH.D. PAPER 3509E **Directional observations on delayed signals on an ionospheric forward-scatter circuit** *May 1961*

F. A. KITCHEN, B.SC., W. R. R. JOY, B.SC.(ENG.), *and* E. G. RICHARDS, M.SC. PAPER 3501E **Some factors influencing 3cm radio-wave propagation oversea within and beyond the radio horizon** *April 1961*

D. R. W. THOMAS, M.B.E. PAPER 3472E **Probabilities of interference with mobile field radio derived from a field-strength survey at 59 Mc/s** *May 1961*

A. H. BALL *and* W. NETHERCOT, M.A., B.SC. PAPER 3550E **Radio interference from ignition systems** *May 1961*

E. L. E. PAWLEY, O.B.E., M.SC.(ENG.). PAPER 3560 **B.B.C. sound broadcasting 1939–60** (Review of progress) *May 1961*

PROF. D. GABOR, DR.-ING., F.R.S., *and* P. C. J. HILL, PH.D. PAPER 3507E **Television band compression by contour interpolation** *May 1961*

F. H. JAMES. PAPER 3502E **The effects of parasitic modulation on the accuracy of measurement of the Q-factor of a resonator** *March 1961*

S. HARKNESS *and* F. J. WILKINS, B.A., B.SC. PAPER 3335M, OCTOBER 1960 **The design of an audio-frequency amplifier for high-precision voltage measurement** *March 1961*

J. J. HILL, B.SC., *and* A. P. MILLER. PAPER 3296M, SEPTEMBER 1960 **The design and performance of high-precision audio-frequency current transformers** *March 1961*

J. J. HILL, B.SC. PAPER 3297M, SEPTEMBER 1960 **Techniques for the calibration of standard current transformers up to 20kc/s** *March 1961*

D. L. H. GIBBINGS, B.E., B.SC., PH.D. PAPER 3519M **A circuit for reducing the exciting current of inductive devices** *May 1961*

Communication on **Storage time of a transistor with a decaying turn-off current**

PART C. MONOGRAPHS (MARCH 1961)

See the Journal for March 1961, p. 179

OBITUARY

PROSPER BARNABY FROST

Prosper Barnaby Frost, B.SC.(ENG.), who died on the 24th October 1960 was born on the 11th June 1887. He was educated at Enfield Grammar School and completed a two-year course in electrical engineering at Finsbury Technical College in 1905, which was followed by three years' workshop experience with Edison and Swan, Enfield, and at Siemens Bros. dynamo works, Stafford. He spent one year with the London County Council in a high-voltage substation of the Transport Department before joining the Post Office Engineering Department in 1909. During this period he studied part-time at King's College, London, and at Regent Street Polytechnic.

Apart from serving as an officer in the Royal Engineers (Signal Company) during the 1914–18 War, when he saw service oversea, and a brief spell in the London Telecommunications Region in 1937, the whole of his official career was spent in the Post Office Engineer-in-Chief's office.

After several years in the exchange equipment and accommodation branch, he joined the external plant and protection branch in 1934 and was its head from 1937 until his retirement in 1950. In this branch he specialized in problems of interference with communication systems arising from power systems, and corrosion damage attributable to natural causes and leakage currents from d.c. power and traction networks. In the course of this work he represented the Post Office on many Institution, Electrical Research Association and British Standards Institution committees and at the conferences and study groups of the C.C.I.F. and C.M.I.

Particular aspects of this work which were near to his heart were those concerned with the joint construction of power and communication systems, protective multiple-earthing of rural distribution networks, and earth-leakage circuit-breakers. In all these, his first interest was safety of human life, and this was also very much his inspiration in the studies undertaken for the departmental Experimental Changes of Practice Committee. His approach to these problems was essentially a practical one, reflecting his earlier training; he rarely took on trust the views of other engineers, however eminent, but always tested them against his own experience or subjected them to experimental verification.

He was a lifelong vegetarian, devoted to the simple way of life, and a keen amateur naturalist. During his time at Stafford he was an enthusiastic cyclist and camper, and in later years an ardent skier, walker and painter. He made many friends in his private life and in his profession, both at home and abroad. These and his former colleagues and staff will remember him as a sincere, modest and kindly person who always took a great interest in their well-being and happiness.

He joined The Institution as a Student in 1905 and was elected an Associate Member in 1912 and a Member in 1934. A paper 'Practical aspects of telephone interference arising from power systems' of which he was part-author was published in the *Journal* in 1946.

E. F. H. G.

EDWARD CURZON LINAY

Edward Curzon Linay, manager, Sleaford District, Lincolnshire Sub-Area, East Midlands Electricity Board, who died on the 30th December 1960 was born at Worksop, Nottinghamshire, on the 5th March 1895. He was educated at Ashley House School, Worksop, and at King's Lynn Technical Institute. He spent his early years in the Electricity Department of King's Lynn and Worksop Corporations, except for a period during the 1914–18 War when he served with the London Electrical Engineers and Electrical and Mechanical Company. In 1919 he was appointed assistant electrical engineer to the borough of Worksop. In 1934 he became chief engineer and manager of the Sleaford undertaking, a position he held until nationalization in 1948 when he was appointed manager of Sleaford District, and he was on the threshold of completing 50 years' service in the industry when he died.

He was quiet, reserved and studious and a very kind man, particularly to those who were in trouble, an attribute well recognized and much appreciated by his district staff, who respected and esteemed him, as did many of his other colleagues in the Electricity Board.

Outside his family he had few interests, and his hobby was his work, from which he derived obvious pleasure and concerning which he was known to say that he had no regrets in selecting the supply industry as his profession. He is survived by his widow, a son and two daughters.

He joined The Institution as a Graduate in 1920 and was elected an Associate Member in 1930 and a Member in 1955.

J. P. T.

JOHN ROLAND SPANSWICK

John Roland Spanswick, B.SC.(ENG.), who died on the 4th December 1960 was born at Streatham on the 4th November 1911. He was educated at Dulwich College and attended evening classes at Battersea Polytechnic while an indentured apprentice with Waygood-Otis. In 1935 he passed the B.Sc.(Eng.) examination with second-class honours and in the same year joined the Electric Furnace Co. as assistant to the chief engineer. In 1943 he was appointed engineer at their Weybridge works, in charge of arc furnaces and mains-frequency induction furnaces, and was responsible for a large number of installations of both types of furnace during the Second World War.

At the end of the war he was responsible for the development of a range of radio-frequency induction-heating equipment. In 1946 he was seconded to the Ministry of Aircraft Production for a British Intelligence Objectives Survey visit to Germany. In 1952 he was appointed chief engineer and manager of the engineering department of the Electric Furnace Co. and in 1955 was made a director. He made many visits abroad on behalf of the company, including trips to the United States and Canada.

In 1959 he joined English Electric, Stafford, as manager, thermal process section, Metal Industries Division. He represented this company on a number of British Electrical and Allied Manufacturers' Association and other committees and travelled abroad on their behalf.

His last illness was sudden and mercifully brief.

He was charming and friendly, popular with all with whom he had business or social acquaintance. In his younger days he had been a keen cricketer, being a member of Surrey County Cricket Club. He was a past master of the Wandsworth Borough Council Lodge of freemasons. He was a keen family man and took a great interest in religious and social activities at St. Peter's Church, Woodmansterne, where he was a sidesman. He was a past-chairman of the Woodmansterne Conservative Association. His principal hobbies were photography and radio mechanics, and he was also interested in home decorating and music. He is survived by his widow and four sons, the eldest of whom is following his father's profession.

He joined The Institution as a Student in 1933 and was elected a Graduate in 1935, an Associate Member in 1947 and a Member in 1959. He was also a Member of The Institution of Mechanical Engineers.

J. E. G.

LESLIE CHARLES THORNTON

Leslie Charles Thornton who died on the 4th December 1960 was born in St. Petersburg, Russia, on the 2nd May 1887. His father was at that time associated with Thornton Woollen Mills, a family concern, which had been established for many years in Russia. He was educated at Hawtreys, Westgate, and at Health Mount School, Hampstead, in England, and at Grünberger Technischer Schule, Silesia, in Germany. He was apprenticed to the Grünberger Carpet Co. and to Kohler and Co., Moscow.

In 1910 he took up a position as erection engineer with Dick, Kerr, Preston. He returned to Russia in 1912 to work on the electrification of the Moscow tramways. He then became manager of a local cable factory, an appointment he held until the first year of the revolution. He joined the British Army in Moscow and saw service in South Russia and the Middle East before being demobilized in England.

In 1920 he joined the British Dynamo Co., London, for three years before being engaged by Metropolitan-Vickers for erection work on the first of the post-revolution thermal power stations being constructed in Russia, ultimately being appointed chief erection engineer.

In 1934 he was appointed conjointly by Metropolitan-Vickers and English Electric to take charge of the electrification of the

Warsaw junction railway. He was still in Poland on the declaration of war in 1939, and, after arranging his wife's departure in one of the last trains going eastward, he successfully organized his own escape to the United Kingdom, where he was seconded for work in British Government factories, later becoming superintendent of the Hirwaun factory in South Wales.

At the end of the war he returned to his company to be appointed engineer and representative in charge of their Turkish Catalagzi contract, which involved the complete supply of a thermal power station, township and system near Zonguldak on the north coast of Anatolia. He retired in 1956.

He will be remembered for his kindly and generous disposition. While his main hobby was his work, he found relaxation in horse-riding and wood carving, at both of which he was an expert. He is survived by his widow and a married daughter, his only son having predeceased him some years ago.

He joined The Institution as a Graduate in 1928 and was elected an Associate Member in 1928 and a Member in 1940. H. C. Y.

New engineering course for technicians

In a memorandum to local education authorities, Sir David Eccles, Minister of Education, outlined details of a new general engineering course for young school-leavers. This is the first of the general courses foreshadowed in the recent White Paper (Cmnd. 1254) 'Better opportunities in technical education', which was summarized on p. 97 of the February 1961 *Journal* in an article by Sir Willis Jackson.

The new course is designed as a one- or two-year 'general course', intended for school-leavers who show promise of being able to qualify as technicians. The course will be introduced into technical colleges in Autumn 1961. The technical subjects in the syllabus will require about 240 hours per year, and the scheme also provides for the inclusion of English and general studies.

An interesting feature is that the course offers a common grounding for students in the various branches of civil, electrical and mechanical engineering.

Qualifications and examinations

Students will enter the course immediately on leaving school; their admission will be at the discretion of the principal of the college concerned. The standard of the subjects in the course will reach to approximately that of the Ordinary National Certificate. Care in selection at this stage is of special importance in reducing the amount of educational 'wastage'. Colleges are enjoined to closely diagnose students' ability through contacts with schools and employers. As well, the first part of the session is to be used as a diagnostic period.

The course is broadly designed and, depending on local conditions, may be provided by block release or part-time day release or as a sandwich course. In each year, the course comprises: engineering science, mathematics, workshop processes and materials, engineering drawing, English, and general studies.

To be eligible for entry to the examination, students must have satisfactorily completed the course of study; the principal of the college will be required to furnish a certificate verifying this. The examination for the general course will be an extended one and will include:

1. A 2½-hour paper on engineering science
2. A 2½-hour paper on mathematics
3. A 2½-hour paper on workshop processes and materials
4. A 3-hour paper on engineering drawing.

Students who succeed in the examination will proceed either to an Ordinary National Certificate course or to one of the various courses for engineering technicians. Unsuccessful candidates will be allocated either to the first year of a technician course or to a craft course as is deemed appropriate.

POST OFFICE LINKS FOR I.T.A.

Five new British Post Office vision links began operation when the Independent Television Authority's service was extended to the south-west of England on the 29th April 1961.

One link interconnects London and Bristol by coaxial cable, and another interconnects Bristol and Plymouth by line-of-sight radio transmission; the third and fourth, using line-of-sight radio transmission, connect Plymouth with the new I.T.A. broadcasting stations at Stockland Hill in Devon and at Caradon Hill in Cornwall; and finally, the studios are joined by coaxial cable to the national television network at Plymouth.

Details of links

The London–Bristol link is effected by a coaxial cable containing six tubes, two of which are used for television and the remaining four for the telephone trunk service. The vision circuit, 140 miles long, is furnished with carrier-line equipment to operate in the ½–4 Mc/s frequency band.

The Bristol–Plymouth radio link, 125 miles long, contains four intermediate repeater stations. The radio link to Caradon Hill is 16 miles long, while that to Stockland Hill is 67 miles long and proceeds through two of the intermediate repeater stations of the main Bristol–Plymouth route. Thus programmes may be fed to the I.T.A. transmitters either from the studios in Plymouth or from the national network, accessible at Bristol or London.

The radio equipment on these links operates at frequencies of about 4000 Mc/s. Each radio link is provided with protection equipment that will be switched into service in breakdown conditions. An unusual aspect of the repeater stations is that radio signals are amplified directly at microwave frequency.

The stations have been built on high ground to ensure that each station is within line of sight of the next, and care has been taken in design and choice of location to mitigate the loss of amenities in the surrounding countryside.

Storing radioactive wastes

Scientists and engineers of the Chemical Engineering Division, Atomic Energy Research Establishment, U.K.A.E.A., Harwell, are working on a method that is expected to simplify the storage of highly radioactive waste.

The plan involves the conversion of waste into insoluble glass-like solids. The glass is produced by mixing a slurry of silica and borax with a nitric acid solution of the concentrated liquid wastes; this is evaporated to red heat, sinters, melts, and, on cooling, solidifies. A typical product might contain from 20 to 30% by weight of waste oxides.

SOME RECENT BOOKS

PHYSIQUE ET TECHNIQUE DES TUBES ÉLECTRONIQUES—Vol. 2

R. CHAMPEIX

PARIS: DUNOD. 1960. 427 PP. 58NF

THIS is the companion volume to 'Éléments de technique du vide' and is an introduction to the theory and construction of electronic valves.

This volume is in two parts. In the first section the author begins by developing the basic physics of electrons in solids and of electronic emission. He then deals with pure-metal and composite cathodes and the behaviour of free electrons in electric and magnetic fields. A treatment of the principles of operation of typical valves follows. This portion of the work is a lucid introduction to electron tubes, at advanced student or graduate level, with emphasis on the physical principles involved.

The second part is called 'technology'. Here the author has attempted to compress his material too much, and the treatment is uneven. The information on metals is so sparse that it is almost useless, while much space is taken by descriptions of elementary manipulation of glass tubing, better suited to an instruction manual.

If the author had continued to give the physics of the processes described, the second section of the book would have appealed to the same kind of mind as did the first. As it is, part 2 tends to be a collection of know-how. A separate volume on technology, of the same standard as Vol. 1 and part 1 of this volume, would have done justice to the author's intentions.

M. ESTERSON

FIELD THEORY OF GUIDED WAVES

R. E. COLLIN

McGRAW-HILL. 1960. 606 PP. £6 8s.

IN principle, most waveguide components can be designed from theoretical solutions of the appropriate electromagnetic-field problems, and during the last 20 years intensive efforts have been made to develop techniques by which results of adequate accuracy for engineering purposes can be obtained with relative ease. Prominent among such methods are the quasi-static and the variational approaches. At the same time the introduction of relatively advanced mathematical techniques, such as the Wiener–Hopf method for solving integral equations, has increased the number of types of problem which are amenable to exact solution.

The exploitation of these methods is a matter for the microwave engineer, and this book is welcomed as the first comprehensive account of the many theoretical weapons which are available to him. The prospective reader may be daunted by the magnitude of the task which confronts him—for example, the relatively unfamiliar concept of a dyadic is widely used. He may take comfort from the fact that the author is himself an electrical engineer, and should begin by studying the mathematical appendix which gives an adequate summary of the tools used in the main text.

The bulk of the volume is devoted to a comprehensive treatment of the basic properties of modes in cylindrical waveguides filled with a homogeneous medium. This lays the foundation for a full discussion of the solution of problems involving discontinuities, including probe, loop and aperture couplings. Specific examples of inhomogeneously filled guides, periodic structures and artificial dielectrics are also covered.

The material is admirably presented, and the reviewer is convinced that this will become the standard reference for many years to come. It can be confidently recommended to research workers in this field who have a theoretical interest, and it will be most valuable for the increasing number of engineers who embark on microwaves as a postgraduate study.

J. BROWN

ELECTRICAL THEORY ON THE GIORGI SYSTEM

P. CORNELIUS

CLEAVER-HUME. 1961. 187 PP. 32S.

THOSE who have seen the almost complete adoption of the M.K.S. system of units in electrical engineering teaching during the last decade or so may wonder whether a book on electrical theory *not* based on the Giorgi system would be acceptable to engineers today. The specific reference to this system in the title has, however, a particular significance, since the author played a considerable part in the missionary work that gained for this system its present general approval.

This is the first English edition (revised and enlarged) of a work first published in Dutch and issued also in French and German. The author sets out (and succeeds admirably) in showing how conveniently the use of M.K.S. units permits basic electrical concepts to be derived and described in an acceptable and informative way. The symmetry of the conduction, in electric and magnetic fields, which emerges so strikingly when described in M.K.S. units, forms the basis of the treatment, but this symmetry is not allowed to obscure the essential differences of these fields.

The volume is particularly recommended for the teacher and the practising engineer; to some extent the student today who is already using M.K.S. units may feel some surprise at pleas on behalf of a system which is already accepted by him. It could, however, be of great value to him, as it is lucidly written and translated and introduces systematically most of the fundamental concepts of electromagnetism.

A useful concluding chapter deals with the history of the Giorgi system and the ease with which dimensional analysis can be performed in terms of the units volt, ampere, metre and second. Passing reference is made to the emergence of the concept of the 'quantity calculus' in connection with units and rationalization, and its pitfalls; this thorny subject is not, however, allowed to disturb the harmony of the main thesis of the text.

E. BRADSHAW

A SHORT HISTORY OF TECHNOLOGY

T. K. DERRY and T. I. WILLIAMS

OXFORD: CLARENDON PRESS. 1960. 782 PP. 38S.

THIS book is described as a sequel to the well known 'History of technology', a 5-volume work to which several members of The Institution have contributed sections.

The present text is a technological *multum in parvo*. Its span is from palaeolithic times to A.D. 1900, with the implied advantages and attendant disadvantages of such a wide range. Inevitably, from so remote a beginning, valuable space is devoted to speculation, and the authors at times appear to be at pains to demonstrate the obvious (e.g. p. 190).

All major forms of human industry, and many of the lesser-known arts, are discussed in relation to their historical background, and the authors have succeeded in catering for the needs of the general reader, who can derive from a single volume a survey of technological history.

Within the limited compass of the volume, the authors have been compelled to develop a brevity of style that may appear facile to those with some acquaintance with the subject-matter and perhaps, in a few instances, misleading (e.g. on p. 25 'aureus' of Constantine where 'solidus' is presumably intended).

The first 200 or so pages which lead up to A.D. 1750 are strongly charged with the history of the ancients. The ensuing 450 pages bring the story of the development of technology from 1750 to 1900 in the form of short sections on numerous subjects, among which 'The electrical industry' comprises 24 pages. Herein are several matters that give rise to comment. The reference to the decomposition of water on p. 610 could well create the impression that this discovery followed that of the voltaic battery; in fact it takes precedence, having resulted from experiments with the influence machine.

A passage on p. 610 appears to confuse the discoveries of Faraday with those of Ampère, and this surely needs clarification in any subsequent edition. From p. 611 onwards the remainder of the section devoted to electricity seems to have been derived from a contribution to Vol. 5 of the larger work from which also a number of the illustrations are taken. The reference to the Ferranti armature is an inaccurate simplification of a passage which refers to a disc armature with strip-copper winding.

On p. 631 it is inferred that the arc lamp was superseded soon after 1880. In fact, lamps of this type were used in London for shop lighting until around 1918 and for street lighting until the 1930s. The wording of paragraphs 1 and 3 of the sub-section 'The electric motor' needs reconsideration; overhead shafts and belt drives were common in this country at least until 1920.

The work includes an interesting section on 'Coal and the metals' but does less than justice to Bessemer on p. 482 by inferring that in America he started where Kelly ceased; in fact, Bessemer was granted the first American patent.

Notwithstanding these minor criticisms, the new book, which is well produced and copiously illustrated, represents good value for the senior student and adult reader to whom, from the style of its writing, it is presumably addressed.

C. MACKECHNIE JARVIS

CONTROLLED THERMONUCLEAR REACTIONS

S. GLASSTONE and R. H. LOVBERG

NEW YORK: VAN NOSTRAND. 1960. 523 PP. £2 2S.

SINCE the controlled release of nuclear energy from the light elements became a declassified topic in 1958, there have been a large number of publications on this subject. However, the text by Drs. Glasstone and Lovberg is the first to attempt a systematic presentation of the material now available. Throughout its wide scope the book maintains the excellent clarity of expression that we have come to expect from publications with which Dr. Glasstone is associated.

It is arranged in 13 chapters. The first three cover the basic concepts and physical conditions for thermonuclear reactions and for controlled fusion. Chapters 4, 5 and 6 deal with elementary plasma theory, the formation and heating of a plasma, and plasma diagnostic techniques.

The next five chapters are devoted to detailed discussions of the pinch effect, the Stellarator, magnetic-mirror systems, the Astron and other miscellaneous proposals for plasma confinement and heating.

The last two chapters cover energy losses and scaling laws, and plasma-stability theory. All the chapters are well referenced to the originating work.

The authors and publishers are to be congratulated on the high standard that has been achieved in this publication. This authoritative introductory treatise to the topic of controlled thermonuclear reactions will be widely welcomed by physicists and engineers.

It is a volume that many working in the field will feel it necessary to have on their bookshelves. D. W. FRY

APPLICATIONS OF THERMOELECTRICITY

H. J. GOLDSMID

NEW YORK: JOHN WILEY. LONDON: METHUEN. 1960. 118 PP. 10S. 6D.

DURING recent years the systematic study of semiconductors has led to a large increase in the efficiency of thermoelectric devices and thus to an awakening of interest in all aspects of thermoelectricity.

The present Methuen Monograph, whose author has made important contributions to the subject, is therefore to be warmly welcomed.

The first quarter of the book deals with the derivation of the Kelvin relations between the various thermoelectric effects, and with the general theory of thermoelectric devices. This section will be of considerable interest to the electrical engineer and so also will the last three chapters, which are concerned with the preparation and evaluation of materials and with applications of thermoelectricity.

In the intervening chapters the author gives a brief account of the factors that determine the choice of semiconductors for use in thermoelectric devices. The subject is an extremely complex one, and this part of the text will probably be largely unintelligible to anyone who is not already well grounded in the theory of the solid state. However, the volume as a whole can be recommended without reservation. C. W. OATLEY

RADIO TRANSMITTERS

L. F. GRAY and R. GRAHAM

McGRAW-HILL. 1961. 462 pp. £4 17s.

THIS gives a description of radio transmitters of all types, ranging from sound and television transmitters to those used for radar and navigation purposes. The book contains an outline of radio amplifiers and circuits used in transmitters and covers the questions of frequency control, modulation, control circuits, cooling, special components, transmitter performance, and measurement.

A basic knowledge of electrical engineering is required to appreciate this work, but care has been taken to keep the mathematics at a relatively simple level. Most of the design outlines involve simple arithmetic and a common-sense appreciation of the engineering problems. Unfortunately, this simplicity has defeated its own object in some sections where mathematics is used for explanatory purposes. For example, in the section on directional couplers the analysis omits to mention one or two simple setting-up conditions that are necessary before the quoted results can be deduced from the derived equations.

European readers may find the references to American transmitter and broadcasting practice slightly misleading, particularly in relation to the chapters on television.

The text provides an excellent introduction to the subject of the design of transmitters and will be particularly useful to those concerned with the operation and maintenance of broadcasting stations. In addition, those who wish to obtain a general idea of the problems in this branch of engineering will find the volume clear and enjoyable to read.

P. GODFREY

NONLINEAR ELECTRICAL NETWORKS

W. L. HUGHES

NEW YORK: RONALD PRESS. 1960. 313 pp. $10.00

THE author begins with a discussion of some non-linear electrical components and examples of non-linear circuits (e.g. modulators). The graphical solution of non-linear resistive circuits is then presented, the more difficult case of circuits with energy storage (involving differential and not just algebraic equations) being treated after a section of mathematical review.

The major portion of the text is in fact concerned with the response of non-linear energy-storing circuits to sinusoidal and transient inputs, the stability of such circuits, and the examination for possible steady states of non-linear oscillation (limit cycles).

Iterative calculations of the responses are emphasized, techniques suited of course to automatic computation.

The stability of circuits is tested in the phase plane and by the methods of Routh and Nyquist in conjunction with the theory of small perturbations. The concluding chapters deal with non-linear oscillations of second-order systems (for classical examples, cf. the books of Stoker and Andronow) and practical methods of generating subharmonics.

The book is recommended to electronic-circuit engineers since all the examples are in terms of thermionic-valve circuits. Numerical analysts concerned with circuit problems may also benefit from studying the computational procedures developed. Criticisms of the work are, however, as follows: the restricted choice of examples (problems in magnetic amplifiers seems an omission); some discussion of noise in non-linear networks would be helpful for the communication engineer; and feedback-control engineers will find the book disappointing, since attention is concentrated on second-order systems and the author pays little attention to the method of describing functions, even attributing it to Russian authors.

Nevertheless, all classes of engineer concerned with non-linear problems may find the book an easier starting-point than mathematical works on non-linear differential equations.

A. R. M. NOTON

MANUAL OF SCIENTIFIC RUSSIAN

T. F. MAGNER

ENGLEWOOD CLIFFS, N.J.: PRENTICE-HALL. 1959. 101 pp. 36s.

THIS work is intended to serve initially as a grammar textbook and thereafter as a reference during translation. It falls into three divisions: basic grammar, reference, and translation practice. Bearing in mind the 'maturity' of his readers, the author compresses the grammar into 35 pages. Inevitably some important constructions are inadequately explored and difficult concepts not fully explained.

The reference sections, in which the material of the first part is rearranged in the form of tables and lists, incorporate many useful ideas, such as tables for identifying the infinitives from the different forms of the verbs, lists of Russian scientific abbreviations and common phrases, etc. The final sections demonstrate translation techniques and include ten scientific texts, with glossary, for the student to translate.

The volume is admirably suited to the engineer or scientist who wants to 'dip' into Russian scientific literature, although hardly comprehensive enough for one wishing to undertake detailed translation of long articles. A beginner might well find the grammar heavy going and feel in need of supplementary instruction.

The choice of photolithographic reproduction of an apparently typewritten original limits emphasis to the use of underlining, capitals or indentation, which, with the uneven margins, gives the work an amateurish appearance. Several misprints, Russian and English, occur.

M. ST. AUBYN

LA MODULATION DE FRÉQUENCE

J. MARCUS

PARIS: EYROLLES. 1960. 317 pp. 42NF

JEAN MARCUS is an engineer at l'École Nationale Supérieure d'Électrotechnique, d'Électronique et d'Hydraulique de Toulouse. His book is divided into seven chapters, and appendixes follow most of them. The aim has been to present the salient features of the field in each section and then to include mathematical details in the appendixes.

In chapter 1 the standard theory of frequency and phase modulation is dealt with in a concise but comprehensive manner. Useful tables, including Bessel functions, are reproduced, and these enhance the value of the work to the practical engineer. Chapter 2 deals with methods of generating frequency- and phase-modulated signals, and here again the subject is treated in a rigorous way; the limitations of the various circuits are examined critically.

Circuits of limiters and f.m. detectors are discussed in chapter 3, while the fourth chapter is a detailed treatment of noise phenomena. Reception of f.m. is the topic of chapter 5, and here one might possibly have expected more reference to domestic receivers. This aspect is barely considered throughout the entire text.

Chapters 5 and 6 deal with multiplex communication equipment and examples of industrial applications of f.m., these being largely concerned with communication equipment. Although it is impossible to include everything in one volume, a wider choice of examples in this last section would probably have been valuable. The bibliography contains some 60 references to papers and textbooks by authors of many nationalities.

The work is beautifully produced, and the diagrams and tables are clearly presented on the same page as the appropriate text. For the student and the engineer alike, this publication is one of the best available. E. RIBCHESTER

THE COMPLETE SCIENTIST

LEVERHULME STUDY GROUP TO THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

LONDON: OXFORD UNIVERSITY PRESS. 1961. 162 PP. 18s.

IN 1958 the British Association took advantage of a grant from the Trustees of the Leverhulme Trust Fund to initiate an inquiry, under the chairmanship of Sir Patrick Linstead, into the desirability of broadening the education of those intending to become scientists and technologists and to seek answers to such questions as: if desirable, how, and at what stage in the educational process, should this be done; is it compatible with the present over-all duration of the process at school and university; if an extension in duration is desirable, how is this to be achieved and should the extension be general or confined to selected classes of students; and what are the financial implications of any such extension?

The report which has now been published contains data about the time-tables and curricula at successive stages from the lower forms at the grammar school to the postgraduate course; it analyses and discusses these data in an admirably clear and readable manner and, having reached the conclusion that the commitment to specialist studies is too heavy for the normal student in both the later stages of school life and at the university, it poses the problems that must be resolved if this situation is to be changed.

The report gives a much needed quantitative appraisal of a matter that is causing increasing concern. It is to be hoped that it will be supplemented by a similar appraisal of the education of the non-scientist, for the need to arm those who do not intend to become scientists or engineers with a knowledge of scientific method and of the achievements of science and technology is as pressing as, and will probably be more difficult to resolve than, the need that the present report discusses. WILLIS JACKSON

VOM WESEN DER NACHRICHT

G. MEGLA

STUTTGART: HIRZEL. 1961. 204 PP. DM24

GERMAN authors are often endowed with a gift for lucid and logical presentation, which makes them ideal teachers; what happens when the above qualities are displayed for their own sake is shown by this volume.

The first chapter deals with the meaning of information symbols, semantics, and instinctive and conscious communication; the second discusses information channels (mechanical, electrical, acoustic, electromagnetic and optical systems); and the third is devoted to fundamentals of telecommunication in a very popular sense, explaining methods of modulation, transmission and coding. The last section considers animal and human perception and senses and their nervous systems.

The illustrations are throughout of the most primitive kind, either of the block-diagram type or showing, in cartoon form, trains, lighthouses, letter-boxes, etc. I greatly doubt if any engineer would derive much benefit from the study of this light and well written book except for odd bits of information. Examples include the courting habits of bullfinches, the ignorance of the Bambuti pygmies of Central Africa regarding the nature of skis and seals (illustrating that a language does not possess words for matters beyond shared experience), and unusual data from many comparative tables (one line reads: 'switching-off facilities: ear—none, eye—eyelid'). A reader would also learn that a deaf person observing a piano player would conclude that some information was being 'generated'. A. LANDMAN

FOUNDATIONS OF ELECTRODYNAMICS

P. MOON and D. E. SPENCER

NEW YORK: VAN NOSTRAND. 1960. 314 PP. £3 13s.

IN this book the authors deal chiefly, by the usual methods of vector analysis, with the electromagnetic field as described by Maxwell's equations and with the use of these equations in various important applications.

It is shown that the theory rests on five postulates, and the development is entirely macroscopic. For example, no attempt is made to give a physical interpretation of polarization and magnetization, so that an inquiring student will look in vain for an explanation as to *why* iron has a permeability and an insulator a dielectric constant.

Since the basic viewpoint is that of charge, the field in general being the cumulative effect of the positions, velocities, and accelerations of charges, this neglect of the electron (not

to be found in the index) is puzzling. One may well agree with the authors' view that physics is built up of pieces which usually do not fit together to form a logical whole, but the refusal to consider electronic explanations seems to encourage such fragmentation of electrical science.

Another omission is that of energy and forces in fields and electromagnetic systems, surely a fundamental matter for the electrical engineer. Within its limitations, however, the work is stimulating. Its main value lies in the calculation of the field in cases of practical interest, and this is well done. Electrostatic problems, the magnetic field of various circuit configurations, inductance, skin effect, waves, waveguides and antennas are covered in a way that clearly shows the relation between the field and its sources and that illustrates the importance of the vector potential of a current.

Circuit concepts are first introduced in the chapter on waveguides, and it is interesting to find a definition of that rather ambiguous term 'voltage'. It is defined as the line integral, between two points, of the resultant Lorentz force per unit charge, $\mathbf{E} + \mathbf{v} \times \mathbf{B}$, and it depends in general on the path of integration.

It is therefore the algebraic sum of the induced e.m.f. and the fall of potential along the chosen path, and the voltage between the terminals of a generator may be equal either to IR_a or to the terminal p.d., as we please. Such a definition is likely to add to the confusion that already exists, and to give the name of a particular *unit* to a fundamental physical quantity is indefensible. It is as if instead of 'length' we used 'mileage', whether we measured the length in miles or not.

The last two chapters, on moving systems and relativistic electrodynamics, are of considerable fundamental interest. The influence of the authors' other published work is here evident, in a refreshing freedom from dogmatism. First comes an investigation of the general question of transforming observed data from one reference system to another system in relative motion. One such transformation is, of course, the generally accepted one of Lorentz, which is necessary to reconcile Maxwell's aether theory with the principle of relativity and which requires different time-measures in the two systems.

The authors show, however, that a transformation is possible that retains a universal time, provided that the velocity of light is always constant with instantaneous respect to its source, irrespective of the motion of the source after emission. This curious hypothesis has also been suggested recently by Prof. H. Dingle. It is true, as the authors point out, that contrary to general belief we have no direct and unambiguous experimental data on the velocity of light from moving sources.

In the last chapter these conclusions are applied, four-dimensionally, to the electromagnetic field, and here the authors admit that the Lorentz transformation is the only one which leads to a theory consistent with classical experiments on the magnetic effect of moving polarized dielectrics. It is rather odd, however, that the treatment of the ordinary laws of electromagnetic induction is reserved for this chapter. The result is not altogether happy, and Faraday's law $e = -\mathrm{d}\Phi/\mathrm{d}t$ is more generally valid than the authors suppose.

This volume, which includes some useful mathematical appendixes, should provide stimulating reading for an honours student of electrical engineering.

E. G. CULLWICK

PRACTICAL NUCLEONICS

F. J. PEARSON and R. R. OSBORNE

E. AND F. N. SPON. 1960. 208 PP. 37S. 6D.

THIS work presents a series of 49 experiments, mainly in nucleonics but including a few concerned with basic physical constants and electronics, that the authors have decided are of fundamental importance to students taking the courses in nuclear and reactor physics at the Birmingham College of Advanced Technology.

The experiments are chosen to meet the needs of students with differing technical backgrounds and so cover a wide range, from elementary absorption and shielding measurement to more advanced experiments dealing with, for example, coincidence counting and neutron diffusion. A theoretical introduction and detailed experimental procedure are provided in each case, and the first chapter presents information on equipment and radioactive sources and on the statistics of radioactivity. There is a laudable emphasis throughout on the statistical checking of experimental results.

The book should be a useful guide to designers of practical nucleonics courses and to students following these courses, but it should be noted that the text is not free from errors and omissions: for example formula 5.303 is, in its context, wrong; formula 7.401 has been misquoted; the term 'flip-flop' is not, as stated, synonymous with 'scale-of-two'; and the reader is left to guess the significance of the curves in Fig. 39.

J. F. HOGG

THE HALL EFFECT AND RELATED PHENOMENA

E. H. PUTLEY

BUTTERWORTHS. 1960. 263 PP. £2 10S.

THE discovery of the transistor has overshadowed all other developments in the semiconductor field during the last decade. Today, however, considerable attention is being devoted to the exploitation of the thermoelectric effect in semiconductors. This effect offers exploitation in electric cooling devices and direct conversion of thermal into electric energy. Research workers in this sphere, in which a thorough grasp of the relations between physical processes and chemical constitution is essential, will find this latest 'semiconductor monograph' most useful.

It is an attempt to describe recent developments in the study of electronic conduction in semiconductors. It assumes that the reader is familiar with solid-state physics, but the first chapter gives a brief historical review of the development of the ideas of the conduction processes and serves as a useful introduction. The main part of the text is concerned with the interpretation of experimental data on the Hall effect, electric and thermal conductivity, and thermoelectric and galvanomagnetic effects.

A great deal of information about a wide range of semiconductors—both elements and compounds—has been collected. It is questionable whether this information has been assembled in the best way; and although the study of certain sections, such as those dealing with the experimental methods of measurement, would undoubtedly be very profitable to undergraduates, one doubts whether the work as a whole is to be recommended to them. P. POPPER

LINEAR CIRCUITS—Vols. 1 and 2

R. E. SCOTT

READING, MASS.: ADDISON-WESLEY. 1960. 510 PP. 38s. PER VOL.

NETWORK theory and its offshoots appear to have a more central place in American engineering education than in our own. One consequence is a stream of textbooks, most of them competent and some of them excellent, from the various transatlantic universities. These are the main source for private study of the field by English engineers and, despite differences of syllabus and approach, can also be useful to students.

The work under review is intended as an undergraduate textbook (the two volumes are best considered together, since they constitute a coherent treatment whose subject divisions are indicated only loosely by the titles of the two parts). It is elementary in the sense that it assumes little preliminary knowledge and that it proceeds through all the topics of importance to the average engineer towards the fringe of those required by the network specialist.

The order of treatment is a little unusual, but quite logical. The first main section presents network-topology equivalents and general methods of analysis in their simplest form, namely as applied to resistance networks. The second part introduces reactance elements and simple circuits containing complex impedances. Their response waveforms for impulsive and sinusoidal stimuli are found from the differential equations. The treatment of impulsive waveforms and the relation between impulse sources and initial conditions is particularly good. An introduction to convolution allows the extension to arbitrary stimuli.

The third section (in Vol. 2) deals competently with steady-state sinusoidal analysis and relates it rationally to the differential equations and the transient behaviour. The fourth introduces Fourier and Laplace integrals, considering them both as spectral distributions rather than as integral transforms or operators; this viewpoint allows simple physical interpretations to take precedence over mathematical manipulation. Application to a variety of circuits and signals is then covered briefly but clearly.

The result is a work of more distinction than this summary of contents might indicate. The writing is consistently clear and pleasant, with occasional touches of individuality and even wit. The problems are many and well chosen. Moreover, the author knows what is really useful.

Ironically, the network specialist often uses simpler methods than the tiro; he knows, by conscious thought or long practice, how to simplify problems by choice of equivalent circuits or by symmetry; which set of equations will be easier to solve; how to evaluate limiting values at zero and infinite frequency; where to choose an arbitrary origin for a waveform; and many more things which are simple when pointed out but often overlooked. This author is aware of these things, and he attempts to a quite unusual extent to inculcate them into the practice of his readers.

Some minor criticisms: the last few chapters are a little overcrowded, the blurb is inaccurate on one point, and the text has a few trivial errors and too many exclamation marks. But, on the whole, the book is thoroughly recommended as an introduction to a useful and fascinating subject.

K. W. CATTERMOLE

CONTROL SYSTEMS ENGINEERING

W. W. SEIFERT and C. W. STEEG, Jun. (*Editors*)

McGRAW-HILL. 1960. 964 PP. £5 16s. 6D.

THE development of control engineering has produced a delightful play-field for some of the world's most brilliant mathematicians. Ten or more years' work has thrown up theorems of great generality, involving branches of mathematics of which the practising control engineer is hardly aware. Some of these engineers have an uneasy feeling that somewhere in all this mathematics there may be the pearl of wisdom waiting to be translated into a revolutionary practice. It is for these men that this text has been compiled.

This major work of 1000 pages of small print is the collected contributions of 11 mathematically minded control scientists. It was originally produced for a summer vacation course at the Massachusetts Institute of Technology for industrially based postgraduate engineers. Since it contains everything of consequence on the theoretical aspects of automatic control that has been developed since the recent war, it is impossible even to summarize the contents.

Non-linear techniques, sampled-data theory and statistical analysis all receive their fair share of the text. The chapter on basic statistical theory is excellent for the engineer as an introduction to the subject. Otherwise, the volume is too full of mathematical generality to bridge successfully the gap between the postgraduate control engineer and this higher theory. Definitely a book for the reference library.

J. C. WEST

PARAMETRON

H. TAKAHASI and KIYASU-ZEN'ITI (*Editors*)

TOKYO: PARAMETRON INSTITUTE. 1960. 191 PP. N.P.

THE parametron was invented in Japan in 1954 by E. Goto. It is closely related to the better-known parametric amplifier and is a device in which oscillations at frequency f are maintained by varying the reactance of one element of a tuned circuit at frequency $2f$. The variable element may be either an inductor or a capacitor, but ferrite-cored inductors have been commonly used hitherto.

The oscillations at frequency f can exist in one of two possible stable states, which are distinguished by a phase

difference of π radians. Moreover, if the oscillations are periodically quenched, the phase in which they build up can be controlled by a weak input signal of frequency f. The parametron is thus a bistable element that can represent a binary digit, and several parametron computers have been constructed in Japan.

According to the preface, the present volume contains reprints of papers on the parametron that were written before the end of 1955, though several of them were not published until 1959. There is a great deal of overlapping, and it is a matter for regret that the editors were unable to carry out their original intention of writing a textbook on the parametron.

Nevertheless, these early papers will be welcomed by those interested in the subject since they give a great deal of the basic theory, information on how logical elements can be built with parametrons, and some practical details. It is to be hoped that a second volume will deal with the possibility of extending the use of parametrons to much higher frequencies, for it is here that the real interest of the subject lies.

C. W. OATLEY

ELECTRON OPTICS IN TELEVISION

I. I. TSUKKERMAN

PERGAMON PRESS. 1961. 290 PP. £2 15S.

THE high price of this volume may well be a deterrent to would-be purchasers, but it appears to be due to the facts that the publishers expect a somewhat limited market for it and that the book had to be translated from the Russian, the cost of expert scientific translation being high.

However, every effort appears to have been made to keep the price down, and to this end the publishers decided not to reset the manuscript in letterpress but to reproduce the original typescript by photolithography. This somewhat reduces the physical ease of reading but must obviously be accepted in the circumstances.

The text consists of six sections. The first, 'Electron-optical elements of television tubes', qualitatively surveys the various classes of television-camera and display tube. It is regrettable that no mention is made of the work of McGee and Lubszynski in the field of camera-tube development.

The second chapter is a long one dealing with the fundamental principles of electron optics, while the third is much shorter and covers emission systems. The focusing of beams occupies chapter 4, and their deflection chapter 5. The concluding section is devoted to image formation.

Throughout, the author has tried to present the qualitative or physical aspects of the phenomena that he describes, side by side with the quantitative or mathematical aspects. This is a valuable feature of the work and is no doubt derived from the author's experience in giving his course of lectures on this subject at the All-Union Television Research Institute of Russia, on which course this text is based.

The material is clearly expressed throughout, and it may be recommended for use by those engaged in research and development.

D. C. BIRKINSHAW

ELECTROMAGNETIC THEORY AND ENGINEERING APPLICATIONS

J. B. WALSH

NEW YORK: RONALD PRESS. 1960. 286 PP. $8.50

THIS is a textbook of intermediate level, suitable for the third year of a degree course in electrical engineering. The author's chief interest is in waveguides and transmission lines, and a more accurate title would have been 'Electromagnetic theory applied to transmission lines'.

The standard of presentation of the material is well above average. The author shows considerable skill as a teacher. He has read widely and has a real feeling for his subject. The text starts with a lucid presentation of vector algebra suitable for engineering students. Other features that call for special mention are the careful discussion of Faraday's law, an extended treatment of skin effect and a helpful derivation of the transmission-line equations.

The chief failing is that the author does not relate his equations to the actual behaviour of material objects. Permittivity, permeability and conductivity appear chiefly as constants in equations. When the author does venture on an explanation of polarization and ferromagnetism, the treatment is misleading and inadequate. Except for these limitations, the work can be heartily recommended.

P. HAMMOND

ELECTRICAL ENGINEERING PROBLEMS

E. M. WILLIAMS and F. J. YOUNG

McGRAW-HILL. 1960. 294 PP. £3

FOR most electrical engineers a book of *problems* suggests an organized preparation for examination questions, particularly of the numerical type. In the present context, the authors offer the fruits of a fascinating project carried out in the Electrical Engineering Department of the Carnegie Institute of Technology. The text contains more than 100 problems, many with several variants and extensions, 'which for their solution generally require professional skill in the application of electrical science and particularly skill in the planning and conduct of electrical laboratory work'.

These problems are based on those developed at Carnegie to exploit the value of 'problem-centred' laboratory work, an approach in which the more conventional aims of laboratory work, including the training in techniques and in the development of physical understanding of system behaviour, are fringe objectives. The problems are arranged as chapters, each concerned with a particular field, for example the rating of electrical equipment.

Since the philosophy behind this Carnegie experiment is as important as the authors' formulation of a selection of problems, the preface is particularly valuable. It explains fully the aims and means of realization of this form of laboratory activity. It also points out that such work, far from reducing the students' coverage of a scientific syllabus because of the possible time consumed in following false trails, has so stimulated students as actually to have raised standards.

E. BRADSHAW

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated in a footnote

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report C/T122 **The automatic operation of a medium-sized wind-driven generator running in isolation** by J. G. Walker. 12s., postage 6d.

A WIND-DRIVEN generator provided a satisfactory supply of electrical energy to an isolated house. With automatic means of loading, full use was made of the electrical energy potentially available.

Report L/T375 **Detection of organic impurities in insulation** by H. F. Church. 7s. 6d., postage 6d.

A TEST method is described for checking the purity of all materials used in capacitor construction; this technique is expected to be of use in other applications of insulation. The detailed routine procedure given is suitable for inclusion in materials specifications, and a test limit for capacitor materials, which should ensure adequate purity, is suggested.

Report T/T57 **Results of some miscellaneous investigations on various combinations of materials for use in meter-type bearings** by G. F. Shotter. 7s. 6d., postage 6d.

Supplement to reference T/T57 **Further investigations on materials for use in meter-type bearings** by G. F. Shotter. 4s. 6d., postage 6d.

THE miscellaneous experiments dealt with in the report include tests on tantalum, molybdenum and zirconium pivots on sapphire cups, as well as tests on three steel/spinel lubricated units run at 17 g.

The report gives the results of a test on a tungsten/diamond unit run at 17 g dry and the final results of a test on a tungsten/diamond flat jewel lubricated with M.O.2 oil at 30 g: this test was started to enable the form of debris to be determined by means of X-rays.

Finally, Dr. Tagg's calculations on the physical constants of tantalum, tungsten, molybdenum and zirconium are given.

The supplement extends the results for steel/spinel lubricated units to a life of 400×10^6 revolutions. It also deals with previous tests on osmium–rhodium as a pivot material and gives results of further tests on four units using this alloy. Finally, future tests on osmium–rhodium/sapphire units are discussed.

BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION (INC.)

Arc welding electrodes. London, 1961. 5s.

CLASSIFIED lists of British electrodes and a key to American and British standards for electrodes are given in this guide.

ECONOMIC COMMISSION FOR EUROPE

The situation and prospects of Europe's electric power supply industry in 1959–60. United Nations, Geneva, 1961*

THE demand for electrical energy rose rapidly during 1960, the growth rate generally being in excess of the 8·5% average European increase in 1959. The main developments in the electric-power industry are analysed. The influence of changes in temperature on electric-power consumption relative to that of changes in industrial output is examined on a European scale for the first time. Other matters discussed include the state of development in different countries of gas-turbine power plants for electricity supply, and power exchanges across European frontiers.

* Obtainable from Sales Section, European Office of the United Nations, Palais des Nations, Geneva, Switzerland

ELSEVIER PUBLISHING COMPANY

Russian supplement to Elsevier's dictionary of electronics and waveguides by W. E. Clason. Amsterdam, 1961. £2 2s.*

THE terms are listed twice—alphabetically and numerically.

GENERAL SECRETARIAT OF THE INTERNATIONAL TELECOMMUNICATION UNION

Manual for use by the mobile services: provisions relating to the radiocommunication service. Geneva, 1961. n.p.

MOBILE service is defined as a service between mobile and land stations, or between mobile stations. The manual is divided into three parts. Part A contains extracts from the Radio Regulations, Geneva, 1959, dealing with terminology; frequencies; measures against interference; administrative provisions for stations; personnel of mobile-service stations; working conditions; distress, alarm, urgency and safety; radiotelegrams and radiotelephone calls; and miscellaneous stations and services.

Part B contains extracts from the Additional Radio Regulations, Geneva, 1959. Part C contains extracts from the International Telecommunication Convention, Geneva, 1959, together with lists of certain provisions of the Telegraph Regulations and of the Telephone Regulations, Geneva, 1958. In all three parts, only provisions likely to be useful to operators in the mobile services are mentioned.

NATIONAL PHYSICAL LABORATORY

Effects of variations in the ambient air on the calibration and use of ionization dosemeters by G. P. Barnard, G. H. Aston and A. R. S. Marsh. H.M.S.O., London, 1960. 2s. 6d.

THIS publication is a critical survey of the existing state of knowledge of the physical properties of atmospheric air. The majority of ionization dosemeters are sensitive to ambient-air variations, and the survey gives practical working tables of corrections.

ROYAL INSTITUTION OF GREAT BRITAIN

Michael Faraday Advice to a lecturer. London, 1960. 2s. 6d.

THE arrangement of material in this anthology of Faraday's writings is not chronological but as suits the subject. Faraday gives guidance on how the lecturer should appear, his delivery, diction and behaviour, as well as on the use of lecture notes, the duration of a lecture, the choice of experimental demonstrations, etc.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

AERE—M736 **Necessary and sufficient conditions for the hydromagnetic Rayleigh–Taylor stability of a cylindrical plasma** by R. J. Tayler. Harwell, 1960. 2s. 6d.†

EXPLICIT forms are obtained for the analogues of three well known stability criteria: the sufficient condition for stability of the hard-core pinch, Suydam's necessary condition for stability, and the necessary and sufficient condition for stability against interchange perturbations of a system with a magnetic field of constant pitch.

AERE—R3486 **On the determination of magnetic fields in slabs and cylinders by measurement of the time-of-flight or displacement of monoenergetic ions which are projected away from the wall and returned by the magnetic field** by R. T. P. Whipple. Harwell, 1960. 9s.†

IT is concluded that the experimental difficulties are so great that the determination of magnetic fields in slabs and cylinders by measurement of time-of-flight or displacement of monoenergetic ions is not practical.

* Obtainable from D. Van Nostrand Company Ltd., 358 Kensington High Street, London W.14

† Obtainable from H.M. Stationery Office, York House, Kingsway, London W.C.2

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

BARDELL, P. R. 621.318

Magnetic materials in the electrical industry. 2nd edition, revised*

London: Macdonald, 1960. pp. xiv, 320. 22 × 14cm. 32s. 6d.

Discusses the influence of magnetic theory on the development of materials and the applications and testing of permanent magnets and soft magnetic materials. The uses include sound recording, non-destructive testing, and applications in transductors and transducers. There is a glossary of terms and units, and the trade names listed in the subject index will assist in the identification of a number of products. This edition includes a section on magnetic ferrites, and the chapter on magnetic recording has been extended.

CADOFF, I. B., and MILLER, E. (*Editors*) 537.32

Thermoelectric materials and devices*

New York: Reinhold. London: Chapman and Hall, 1960. pp. xiii, 344. 24 × 16cm. £3 18s.

Considers the use of thermoelectric materials for power conversion and refrigeration. The theory of thermoelectric processes and the thermoelectric circuit is first explained. There follow a theoretical and experimental evaluation of materials used as thermoelements and descriptions of some experimental and prototype units that have been built. Reviewed in the April 1961 *Journal*, p. 242.

GIBBONS, G., and JAY, K. 621.039

British nuclear reactors

London: Chatto and Windus, 1960. pp. 32. 21 × 15cm. 6s. 6d.

A very simple account of the structure of the atom, the fundamental principles of the nuclear reactor, and the design of such plants as Calder Hall.

KEMP, P. 537.226

The dielectric circuit (Monographs on electrical engineering, Vol. 16)*

London: Chapman and Hall, 1960. pp. ix, 219. 22 × 14·5cm. £2 5s.

The treatment is confined to basic principles. It is concerned with dielectric phenomena in h.v. circuits, including transient conditions, and refers particularly to transmission lines and cables. A review appeared in the April 1961 *Journal*, p. 243.

LANG, R. (*Editor*) 53

Laboratory and workshop notes 1956–58: a fifth selection reprinted from the *Journal of Scientific Instruments*

London: Edward Arnold, 1960. pp. xii, 218. 22 × 14·5cm. £2

LOUISELL, W. H. 621.375.9

Coupled mode and parametric electronics*

New York and London: John Wiley, 1960. pp. xv, 268. 23·5 × 15cm. £4 12s.

Presents a unified theory of travelling-wave tubes, backward-wave oscillators and similar microwave devices from the common point of view of the theory of coupled modes.

MENZEL, D. H. (*Editor*) 621.396.8

The radio noise spectrum*

Cambridge, Mass.: Harvard University Press, 1960. pp. viii, 183. 24 × 16cm. £3

A series of chapters by various authors dealing with the aurora, the ionosphere, meteors, solar activity, noise of planetary origin and cosmic noise.

MEYER, N. I. 621.314.7

Non-linear distortion and small-signal parameters of alloyed junction transistors: a theoretical and experimental investigation with special reference to class A transistor amplifiers at low and medium frequencies*

Copenhagen: Danish Science Press, 1960. pp. 269. 23 × 15·5cm. 35s.

MOORFIELD, S. H., and WINSTANLEY, H. H. 531

Mechanics and applied heat with electrotechnics; a textbook for engineers. **3rd edition**

London: Edward Arnold, 1960. pp. xi, 386. 19 × 12·5cm. 12s. 6d.

This is a textbook for Ordinary National Certificate students. The section on electrotechnics includes an introduction to the M.K.S. system.

NEETESON, P. A. 621.396.615

Analysis of bistable multivibrator operation: the Eccles–Jordan flip-flop circuit. **2nd edition***

London: Cleaver-Hume Press, 1960. pp. viii, 92. 23 × 16cm. 17s. 6d.

RYDER, J. D. 621.38

Electronic fundamentals and applications. 2nd edition*

London: Isaac Pitman, 1960. pp. xii, 721. 23·5 × 15cm. £3 9s.

This is for university and technical-college students. It discusses equally semiconductor and vacuum-tube devices and shows how they can be considered in active networks for purposes of circuit analysis. Besides dealing with their functions as oscillators, amplifiers, rectifiers, etc., it examines more specialized uses, such as in control devices and wave-shaping circuits.

STENDER, R., and McKELVEY, K. K. 518.5

The modern slide rule. 3rd edition

London: Cleaver-Hume Press, 1960. pp. 119. 21 × 14·5cm. 6s.

The early chapters introduce the student to logarithms and the principle of the slide-rule. The ordinary processes of multiplication, division, etc. and the use of the sine and tangent scales are dealt with. Rules with log–log and other special scales are described, as well as more elaborate processes, which are illustrated by worked examples.

TROUP, G. 621.375.9

Masers: microwave amplification and oscillation by stimulated emission*

London: Methuen, 1959. pp. x, 168. 17·5 × 11cm. 13s. 6d.

A discussion of the stimulated-emission process is followed by a brief outline of methods used to obtain the conditions necessary for amplification. The effects of physical processes on amplifier efficiency and on the effective frequency response of a molecular transition used to amplify are described. This book was reviewed in the April 1960 *Journal*, p. 246.

WEBB, H. A., and ASHWELL, D. G. 517

A mathematical tool-kit for engineers. 2nd edition*

London: Longmans, 1959. pp. vii, 116. 21·5 × 14cm. 15s.

Gives concise explanations of mathematical techniques used for engineering problems, including the Fourier series, the Laplace transform and the theory of errors, with worked examples and problems for the student to solve.

WEST, J. C. 621–52

Analytical techniques for non-linear control systems*

London: English Universities Press, 1960. pp. xii, 223. 22 × 14cm. 25s.

Describes in detail the use of the three techniques of the phase plane of non-linear mechanics, the diminishing function, and stochastic processes. Reviewed in the April 1961 *Journal*, p. 246.

OTHER PUBLICATIONS

BRITISH BROADCASTING CORPORATION

A mobile laboratory for u.h.f. and v.h.f. television surveys by E. W. Taylor and L. C. Munn. Engineering Monograph 34

London: B.B.C., 1961. pp. 16. 28 × 22cm. 5s.

COPPER DEVELOPMENT ASSOCIATION

Symposium on recent developments in the use of copper in the electrical industry, held on 19th October 1960 at the Dorchester Hotel London W.1

London: Copper Development Association, 1960. pp. 158. 21·5 × 15cm. n.p.

ECONOMIC COMMISSION FOR EUROPE

The situation and prospects of Europe's electric power supply industry in 1959–60

Geneva: United Nations, 1961. pp. 95. 28 × 21·5cm. 7s.

INSTITUTION OF
POST OFFICE ELECTRICAL ENGINEERS

Railway a.c. electrification and its effect on line communication circuits by L. F. Scantlebury and D. W. R. Cobbe. Paper 217

London: Institution of Post Office Electrical Engineers, 1959. pp. 20. 27 × 21·5cm. 2s. 6d.

INTERNATIONAL COMMISSION ON ILLUMINATION

Proceedings of the 14th session, Brussels, June 1959. Vols. A—Sources of radiation, B—Lighting technic, C—Lighting practice, and D—Lighting and traffic

Paris: C.I.E., 1960. pp. 586. 29·5 × 20·5cm. n.p.

MINISTRY OF POWER

Test and certification of intrinsically safe electrical apparatus and circuits. Testing Memorandum 10

London: H.M. Stationery Office, 1960. pp. 15. 24 × 15cm. 1s.

MINISTRY OF TRANSPORT

Railway accidents. Interim report on the accidents which occurred on 13th and 17th December 1960 in Glasgow suburban electric trains in the Scottish Region British Railways

London: H.M. Stationery Office, 1961. pp. 20. 24 × 15cm. 1s.

SCOTTISH EDUCATION DEPARTMENT

Technical education in Scotland: the pattern for the future. Cmnd. 1245

London: H.M. Stationery Office, 1961. pp. 15. 24 × 15cm. 1s.

UNITED STATES OFFICE OF NAVAL RESEARCH

Quantum electronics. A symposium edited by C. H. Townes. Conference on quantum electronics—resonance phenomena held at Shawanga Lodge, High View, New York, 14th–16th September 1959

New York: Columbia University Press, 1960. pp. xviii, 606. 24 × 16cm. £6

Reviewed in the February 1961 *Journal*, p. 119.

ADVANCED GAS-COOLED REACTOR

THE prototype advanced gas-cooled reactor (A.G.R.) is now in its final stages of construction at Windscale. The United Kingdom Atomic Energy Authority have announced their intention of completing it by July 1961 and handing it over to operations staff for fuel loading in the late autumn of 1961.

Within the reactor vessel, the graphite core and its supports are complete, and the neutron shield has been erected. The precipitators have been installed, and the can-failure-detection pipes are being fitted and connected to them. One gas circulator has been successfully tested on a heat exchanger in design conditions of temperature and pressure, and is now undergoing minor modification. The refuelling machine is being tested at the contractor's works and will be dismantled, transported to Windscale and re-erected.

Construction is virtually complete outside the reactor-containment building: much of the turbine-hall electrical plant is installed, the dump condenser is finished, and erection of the turbine is well advanced.

Hero

The construction of Hero, the zero-energy facility alongside A.G.R., has been delayed, and its handover also is expected in the autumn of 1961. A number of components, such as control-rod mechanisms, have been tested and have proved satisfactory.

More high-power short-wave transmitters

TWO more 100kW twin-channel short-wave transmitters have been ordered by the British Broadcasting Corporation, to be installed at their External Services station at Daventry; these are similar to those recently installed at the B.B.C.'s short-wave station at Rampisham, Dorset (see April 1961 *Journal*, p. 211).

The new transmitters have an over-all efficiency nearly twice that of the old equipment, which will result in an appreciable economy in operating costs.

THE DEVELOPMENT OF PARTICLE ACCELERATORS

IT has been agreed that the development of particle accelerators, previously carried out at the Atomic Energy Research Establishment, U.K.A.E.A., Harwell, shall henceforth be the responsibility of the Rutherford Laboratory of the National Institute for Research in Nuclear Science.

Particle accelerators are important to research in basic nuclear physics. They are also used by the Atomic Energy Authority to obtain nuclear, chemical and metallurgical data for the Authority's reactor-development programme. Until the 1st January 1961, the Research Establishment, Harwell, had carried out an extensive programme of research and development on accelerator design and had built a variety of accelerators. Most of the Authority's personnel engaged in this project have now been transferred to the Rutherford Laboratory of the National Institute; the Institute's prime concern is the design, construction and operation of high-energy particle accelerators for use by the universities.

The services of the Institute will be available to aid the development and construction of new Authority accelerators.

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 1st April 1961

ELECTIONS

Associate Members

ARTHURS, Stanley
BEDINGTON, Rae Cyril
GOODWIN, William Dennis
HEINE, Christian Peter, B.E.
PHILLIPS, James Alexander
PICKLES, Jack
REES, David Thomas, B.SC.
WISE, John Stuart

Associates

CATLIN, Ross Kennedy
COX, Colin Handsley Stewart
DEY, Phani Bhusan, B.SC.
GREENWELL, John Evelyn
GRIFFITHS, Albert Edward
LORD, Ronald
SETTELEN, Max
TILLMAN, Frank Albert
WAITE, Nigel Windsor

TRANSFERS

Associate Member to Member

ATTARD, Anthony, M.B.F.
CORCORAN, John Francis
DAWSON, Robert James
EDNEY, Brig. Alfred John, C.B.E.
GOPALAKRISHNA, Hiremagalur Venkatadasappa, B.SC., B.E., D.ENG.
HIX, Capt. Lucien, B.SC., R.N.
LOCKE, Cmdr. Cyril Frederick, R.N.
McMULLIN, Terence Alexander, B.SC.
POOL, Lt.-Cmdr. Norman Hector, R.N. (RET.)
SCOTT, Col. Conroy
SHACKLETON, Capt. Norman
THORPE, Lt.-Col. Leofric Egerton, R. SIGNALS (RET.)
WOODFORD, Eric Victor
WRIGHT, Sidney Thomas

Associate to Associate Member

BRUCE, Herbert Baillie
HARDY, Rowland, M.SC.

Graduate to Associate Member

ANDERSON, Dennis Hugh Hylton
BARCLAY, Ronald
BENNETT, Denis Vernon
BRYANT, Allan Victor
BUSHELL, Arthur James
COCKMAN, Maj. Roland Maurice, B.SC.(ENG.), R.E.M.E.
COOK, James William, B.SC.(ENG.)
CURLE, James Leonard
CYSTER, William John
DANIELS, Ronald Charles
DAY, William David
DEAN, Kenneth John
EDKINS, Peter George
FRASER, James
FREEMAN, Ernest Allan, PH.D., B.SC.
GOODIER, Geoffrey Thomas, B.SC.
GRANT, Henry Charles
HARPER, John Alfred
HEATON, John
HITCHING, Frederick Paul
IRVING, Thomas James Jardine
JOHNS, Rex William
JORDAN, Thomas Alfred, B.SC.(ENG.)
KINSON, Harold
LAMBARD, Bernard Ralph
LOWRY, Peter
LUSTIG, Edmund, B.SC.(ENG.)
McCAUSLAND, Ian, M.SC., PH.D.
MADDOCK, John Evans
MAWLAM, William
MORGAN, William Alfred
NEWELL, Joseph
NICOLL, Alfred, B.SC.(ENG.)
NORMAN, Frank James, B.E.E.
PETERSEN, Marinus Robert George
QUINNEN, Ronald
RACZKO, Henry
ROWLINSON, Leslie
SARKAR, Goutam, B.E.
SHAH, Manubhai Ambalal, M.E.
SHELTON, George Leslie
SMITH, Frederick George
THOMAS, Godfrey
VAZ, Eric Clement, B.E.
WALLIS, Hugh Roland Doswell
WARREN, Kenneth Roy
WICKEN, Geoffrey William
WILKINS, James Humphrey
WILLIAMS, Vernon Albert, B.SC.(ENG.)

Student to Associate Member

LENNOX, Colin Graeme, B.SC.(ENG.)
NEWPORT, Christopher Bourne, B.SC., PH.D.

The following elections and transfers approved by the Council of The Institution are effective from the 6th April 1961

ELECTIONS: 1st LIST

Graduates

AKINSETE, Vincent Alaba, B.A.
ANDERSON, John Boyd, B.SC.
BENNETT, Graham Leslie, B.E.E.
BONTHRONE, Alexander Brewster
BRAMLEY, Alfred
BROWN, Alan Rostron, B.SC.
BYRNE, John Patrick, B.E.
CLARK, Robert Arthur, B.SC.
COBDEN, Henry George
COOPER, Graeme John, B.SC.
DOUGLAS, Thomas James, B.E.
DUNN, David Peter
DUNNE, Thomas Francis
EARNSHAW, Rodney Lawson
FROST, Martyn Henry
GORE, Michael Miles, B.SC.
GREGORY, David Neil, B.A.
HARRIS, Robert
HATT, Ronald John, B.SC.(ENG.)
HIRST, Paul Barnard

Graduates (continued)

HOLTHAM, Arthur Clive
IVKOVIC, Radmilo, B.A.SC.
JEFFREYS, Robert, B.SC.
JOE, Sing He, B.E.
LELLIOTT, Sidney Robert, B.SC.(ENG.)
McCARTHY, Joseph Ignatius, B.E.
MAKIN, Peter, DIP.TECH.(ENG.)
MOFFAT, Matthew Ernest Bruce, B.A.
MOORE, Alan Clive
MORRIS, William Richard
OWEN, Denis Brian Bernard, B.SC.
PEARCE, John Charles Robert
QUINN, Thomas, B.E.
ROSE, Arthur
SOUTHERN, Albert
SZWAGRZAK, Rudolf Jan Maria, B.SC.(ENG.)
TAIWO, Akinola Adebayo
THOMPSON, Geoffrey
WALLIS, David, DIP.TECH.(ENG.)
WATSON, John Barry, B.ENG.
WHITECROSS, Michael John, DIP.TECH.(ENG.)
WILLIAMS, Peter, B.SC.
WOOTTON, Roy Edwin
ZARACH, Jerzy Stanislaw

Students

ASHENDEN, Thomas Philip
ATASSI, Faiez
BAILEY, Alan Gordon Edward
BAKER, Frank Harry
BENDALL, David Stuart
BOLTON, Robert Anthony
BROWNE, Richard Edward Bernard Walker
BUCHAN, James Strachan
BURBRIDGE, Laurence
BURRIN, Alfred George
BUTLER, Frederick Richard
CLARE, Melvyn Stanley
CLARK, John
COOPER, Norman Henry Rex
CULF, Peter
CUTHBERT, Roger Henry
DE SOUZA, Francis Robert
DIEFFENTHALLER, Trevor Anthony
ECCLES, Walter George Desmond
EDWARDS, John Henry
FAIRLAMB, Trevor Muir
FARRALL, George Arthur
FLINT, Alan John
FLOWERS, Allan
FOX, David Michael
FRISBY, Roger Alan
FRY, Brian Thomas
GARDNER, Terence Boyd
GEE, Bryan Edward
GOLDING, John Ernest
GOSS, Barry
GRACE, Ronald Frederick
GREEN, John Harold
GRIERSON, Alan Michael
GRIFFITHS, Richard Hefin
HARMAN, Clifford Charles
HAWKES, Michael David
HEMINGTON, Rodger Haird
HEMINGTON, William Brian
HIGHAM, Derek, A.R.T.C.
HILL, George Leonard
HOLLAND, Michael John
HOOD, David
HUGGETT, Christopher Douglas
HUNTER, Kelvin Ernest
HUNTER, Stuart John
IOANNOU, Dinos Neophytou
JACK, David Michael
KAPUR, Kamal Kumar
KELLY, Edward John
KENDRICK, Charles Leslie Terence
KING, Robert Frederick
LOYNES, Barrie Neill
MACEDO, Francis Xavier
McWHA, James
MAHER, James Anthony
MICHAEL, Peter Colin
MOFID, Ghavam
MORLEY, Eric
MORSE, Michael Joseph
NG, Kim Chew
O'NEILL, John Nicholas
PAGE, Michael Geoffrey
PARRATT, Alan Lawrence, B.ENG.
PINK, David John
PITT, Martin
POET, Robert Thurlbeck
PRATSCHKE, Anthony Edward
RATTRAY, William Gilbert
REANEY, Michael John Frederick
REDHEAD, Ian David
RUSSELL, Ian David
SALEN, Roger
SCHMIDT, Ruediger
SENDLES, David John
SEYMOUR, Clive Ronald
SMITH, Colin
STARBUCK, David Harold
TATTERSALL, Peter
TAYLOR, Peter
TIPPEY, Michael
WALLS, John Nicholas David
WHEATLEY, Philip
WHITE, Dennis
WILLIAMS, Eddy
WONG, George Shoung Koon
WOODFIELD, Brian Keith Hylbert
WRIGHT, Michael David

TRANSFERS: 1st LIST

Student to Graduate

BOOTH, David Frankland, B.SC.(ENG.)
BROWN, Frank Walter Edward
CONDLIFFE, William Harvey, B.SC.
COODE, Edward John, DIP.TECH.(ENG.)
COWLEY, Alan
DOWN, Bryan, B.SC.
FINCH, Geoffrey Paul, B.A.
GILES, Brian Joseph, B.SC.(ENG.)
HALSTEAD, David Barry, DIP.TECH.(ENG.)
HALSTEAD, Donald Francis, B.ENG.
HARDING-JONES, Peter, B.SC.
HARRIS, Martyn Rutherford, B.SC.(ENG.)
HENRY, Colin Hannah, A.R.C.S.T.
HUDSON, Richard Mervyn
JOHNSON, Brian Keith Alexander, DIP.TECH.(ENG.)
KAPLAN, Wilfred Michael, B.SC.(ENG.)
KELMAN, Keith Douglas Edward
KIRKBY, Norman Stephen, B.SC.(ENG.)
LEAMAN, William Mark
LE-MARIE, John Richard
LOCKETT, Anthony David, B.SC.(ENG.)
ORMAN, Gerald Anthony Edward, B.SC.(ENG.)
PATEL, Pushpakant Ranchhodbhai
PERRIN, Jane Elizabeth, B.SC.(ENG.)
POOLEY, John Charles, B.SC.
PRINN, Douglas George, B.SC.(ENG.)
REECE, Capt. Sidney George, B.SC.(ENG.), R. SIGNALS
REED, Donald Brian
RITCHEY, Alan, B.SC.
SAGGAR, Ram Krishan
SANSOM, Colin Albert
SCOTT, Colin
SHAW, Derek, B.SC.(ENG.)
SINCLAIR, Clive Robert
SMART, Derek Bowman, B.A.
STEVENS, Michael Charles, DIP.TECH.(ENG.)
SULLY, David Alan, B.SC.(ENG.)

ELECTIONS: 2nd LIST

Graduates

BARNES, Roger Neville, B.SC.(ENG.)
BOOTH, Trevor William, B.SC.
BRASSINGTON, William John
BURGESS, Ronald, DIP.TECH.(ENG.)

Graduates (continued)

DODDS, Michael Edward, B.A.
ELMS, John Osmond, B.SC.(ENG.)
GALLETLY, George
GRAHAM, Joseph Anthony, B.E.
GRAY, Derek John, DIP.TECH.(ENG.)
HARTLE, Roy, B.SC.TECH.
HESTER, Keith John, B.A.
JENYNS, Richard Charles Gambier, B.A.
JONES, Keith Taggart, B.SC.TECH.
KONWERSKI, Tadeusz, B.SC.(ENG.)
KUNDU, Sourendra Kumar, B.SC.
MABON, Stuart Proven, B.SC.
MALHOTRA, Mohan, B.E.
MARTYRES, Anastasio Reginald, D.F.H.
MAYCOCK, George Philip, B.SC.
MESSENT, Brian Eugene, B.SC.
MILNE, Robert Murdo Tulloch, A.H.–W.C.
MORRALL, David, B.SC.(ENG.)
NOBLE, John Watherston, B.A.
PAPADOPOULLOS, Genethlios Georgiou, D.F.H.
PAXTON, William Grahame, B.SC.
PLANT, Anthony Brian, DIP.TECH.(ENG.)
PYE, Arthur Charles David, B.ENG.
RAWLINSON, John Stephen, B.ENG.
RICHARDS, Clement John, B.SC.(ENG.)
SHENTON, Graham, B.SC.
SMITH, Royle Albert
WATSON, Peter William, B.E.
WILLIAMS, Brian Edward Frank
WILLIAMS, Trevor, B.SC.(ENG.)

Students

AMARASINGHE, Srimath Channa
ARISS, Brian Arthur
ASPINALL, Raymond
BAKER, Derrick William
BAROWITZ, Peter Jack
BAVISTER, Roy Charles
BECKETT, Ralph George
BENNETT, Terence Manning
BERRY, George
BINCH, Michael
BIRT, Leslie Arthur
BURTON, Peter Leonard Arthur
CANNELL, Geoffrey Briggs
CHADDOCK, Norman Edward
CHAPPELL, Richard Arthur
CLARKE, Keith Edward
CLEMENTS, Martin John
COOKE, Brian Anthony
COUSINS, Ralph Martin
DAVIES, Ian
DAY, Maurice Stanley Richard
DIXON, Norman George
DODSON, Gerald Norman
DYKE, Owen Douglas
GUILD, James Brown
HALCRO-JOHNSTON, Hugh
HARDWICK, David William
HAWKINS, James Michael
HAYMAN, Robin Brice
HILL, Charles Edward
HILLING, David Edwin
HOLLINS, Brian Eric
HOWGATE, Peter Vipont
JEFFREY, Christopher Hugh
JONES, Alfred
JONES, William Alfred
JUNIPER, Ian Naidley
KELLY, Gordon Anthony
LAND, David Victor
LEWIS, Henry Norman
LINCOLN, Michael John
MALSHER, Alan George
MARSHALL, Judith Elaine
MATHUR, Satish Chandra, B.SC., B.E.
MOGFORD, Michael Geoffrey
MOHAN, Sundarajan, B.TECH.
MOSS, Christopher Dennis
MUDD, Ronald
NANAVATI, Ravindra Markandrai
OXLEY, Kenneth Arthur
PRABHU, Dayanand Ramanath, B.E.
READING, Keith Norton
REID, Thomas Wesley
ROBERTS, Brian Edward
ROWBOTHAM, Harold
SAMARANAYAKE, Galhenage Dhanapala
SELBY, William
SENEVIRATNE, Sadha Tissa
SHAREEF, Athar Ali
SHERIFF, Philip
SHORT, Michael John
SPARROW, Colin David
THOMAS, Peter Mansel
THOMAS, William George
THOMSON, Hugh Gilmour
URQUHART, Gordon Greig
VIERI, Bruno John
WATTS, Roger Mansfield
WHITTAKER, John Frederick
WILLIAMS, David Charles
WINSBOROUGH, Anthony John

TRANSFERS: 2nd LIST

Student to Graduate

AMOS, Michael John, B.SC.
BALL, Ian Desborough, B.SC.
BARKER, Ronald Stanley, B.SC.(ENG.)
BARRON, Donald Robert, B.SC.(ENG.)
BLANCHARD, Colin Reginald
BROWN, Colin
BUCKNER, Frederick Hugh Percy, B.SC.
BYRNE, Francis, B.SC.
CARTWRIGHT, John Stanley, B.SC.TECH.
CASSIDY, Bernard Francis Desmond, B.SC.
CHAPMAN, John Frederick, B.SC.
CHILCOTT, Sub.-Lt. Benjamin Cardew, B.SC.(ENG.), R.N.
DAVIES, Cyril Allun Havard, B.SC.
DURLING, John Anthony, B.SC.(ENG.)
EATON, Edward Harry, DIP.TECH.(ENG.)
EGLIN, David, B.SC.
ENGLEFIELD, John Henry, B.SC.(ENG.)
FORREST, Ian Naismith, A.R.C.S.T.
FORSYTHE, William, B.SC.
FOWLER, Graham John, DIP.TECH.(ENG.)
GERARD, Roger Edwin John, DIP.TECH.(ENG.)
HALL, David Michael, B.A.
HALL, Kenneth Leslie, B.SC.TECH.
HORNE, Peter John, B.SC.(ENG.)
JEFFERSON, Edgar William Wilson, B.SC.
LAWSON, Denis William, B.SC.
LAY, Rodney Kintore, B.SC.(ENG.)
MACKENZIE, Alastair Graham
MENDELSON, Anthony John, A.H.–W.C.
MORGAN, Eric John, B.SC.
MORT, Colin James, B.SC.
NALIKKA, Henry
NEWBURY, Roger Alan, B.SC.
NIX, George Francis, M.SC.
OULTON, Timothy Norman
OWEN, Alan, B.SC.
PARRATT, Alan Lawrence, B.ENG.
PHILIP, Robert Finlay, B.SC.
QUIGLEY, Michael Bernard Coupland B.SC.(ENG.)
REDDING, David Sheldon
ROSS, Douglas Stuart, B.SC.(ENG.)
SKOTTOWE, Anthony Britiffe, B.SC.(ENG.)
SMITH, Brian Duncan, DIP.TECH.(ENG.)
TRAYLER, Michael John
UMPELBY, Anthony Michael, DIP.TECH.(ENG.)
VAN BINNENDYK, Dirk
WATSON, William Gillbanks, B.SC.TECH.
WATT, Nicol Lumsden, B.SC.
WIGZELL, James Laborda, B.ENG.
WILLIAMSON, David Harry Brian, B.A.
WOLLASTON, Brian Robert Major, DIP.TECH.(ENG.)
WOOD, Alan Ronald, DIP.TECH.(ENG.)

POWER-STATION EFFICIENCY

THE Central Electricity Generating Board saved nearly £3 million in fuel costs during 1960. Over-all average efficiency of the power stations operated by the Board rose to 26·71% from 26·36% for 1959.

Almost a third of the total 102 891 million kWh was supplied by the 20 most efficient stations, which had an average thermal efficiency of 31·49%. The three top stations were Blyth A (34·28%), Agecroft C (34·14%) and High Marnham (33·20%).

Naval commissions for engineering graduates

THE Admiralty have announced a new scheme whereby university graduates with a suitable engineering degree or degree equivalent, up to 25 years of age, may be awarded General List commissions in naval engineering.

Officers entering the Royal Navy under this scheme will serve within the new technical-officer structure created by the amalgamation of the 'Engineering' and 'Electrical' specializations into a single 'Engineering' specialization. This amalgamation becomes effective on the 1st July 1961. Under the new structure, Engineer Officers, both electrical and mechanical, will serve together in one of four groups within the Fleet: marine engineering, weapons and radio engineering, submarine engineering, and air engineering.

Applicants must possess a degree in electrical or mechanical engineering (or in science with suitable engineering subjects) from a recognized university, or a degree equivalent. They should also, preferably, have six months' works experience, including that gained during university vacations.

POST OFFICE FORGES AHEAD

THE Postmaster General, the Rt. Hon. Reginald Bevins, M.P., outlined the expanded services planned by the British Post Office in an address delivered at the opening of Fleet Building, London, on the 11th April 1961.

During the year to March 1962, it was expected to add 300000 lines to the telephone network. This would allow telephone service to be offered to 460000 applicants.

Owing to the record demand for trunk calls, the Post Office expected to increase the number of trunk telephone circuits by some 4000. The twopenny telephone service, which enabled callers to dial their own trunk calls, would be available to about 300 exchanges and a quarter of a million customers by March 1962. London's first instalment of this new service should start by July 1961.

Telephone-billing mechanization

The Post Office has installed at Portsmouth punched-card and electronic machinery to deal with telephone accounting. This is the ninth city to be so equipped, the total cost of the nine installations being about £850000.

At present, some ten million telephone bills are prepared each year. This total will be increased to at least 21 million by 1966 with the introduction of quarterly telephone accounts, which are being re-established with subscriber trunk dialling. However, since most trunk calls will be dialled, the work of preparing individual accounts is expected to decrease.

During 1960, some 800 million individual tickets were prepared for telephone calls. This is expected to fall to 450 million by 1966 and to 350 million by 1967.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 7TH APRIL 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	930	9722	2	1
£2 to <£5	2380	6572	19	4
under £2	31310	16529	17	3
		£48691	1	8

NOMINATIONS

NATIONAL SOCIETY FOR CLEAN AIR—EXECUTIVE COUNCIL

THE Council of The Institution have nominated Mr. A. R. Cooper, M.ENG., MEMBER, as their representative on the above council for a further term during the year 1961–62.

BRITISH ELECTRICAL POWER CONVENTION

THE Council have nominated Mr. B. L. Metcalf, B.SC.(ENG.), MEMBER, as their representative on the council of the above convention for a further term, with the Secretary of The Institution as his deputy.

SEVENTH GRAHAM CLARK LECTURE

ADVANCE separates of the Seventh Graham Clark Lecture 'The engineer in Commonwealth development', delivered by H.R.H. Prince Philip, Duke of Edinburgh, K.G., P.C., K.T., G.B.E., F.R.S., in the Great Hall of The Institution of Civil Engineers on the 13th April 1961 (see p. 333), will be available towards the end of May, and a member wishing to obtain one should apply to the Secretary of The Institution of Electrical Engineers.

The Lecture will be published in full in the June 1961 *Journal*, and separate reprints from the *Journal* will be obtainable at the end of July.

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution, it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested when notifying a change of address to give their full initials, their previous address and their class of membership.

MEMBERSHIP OF LOCAL CENTRES AND SUB-CENTRES

A MEMBER whose registered address is within the area of a Centre or Sub-Centre is automatically attached to the Centre or Sub-Centre concerned and also, if he is a Student or a Graduate under the age of 28, to any Graduate and Student Section within the area. Any member who so wishes, however, may be attached to any Centre or Sub-Centre adjacent to that in which he resides, if this is more convenient to him, by making a request in writing to the Secretary of The Institution.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council of The Institution, the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary of The Institution, giving the date of his call-up.

INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH

THE International Association for Hydraulic Research, founded in 1948, is a world-wide organization of engineers and scientists whose object is to stimulate and promote all aspects of hydraulic research. The Association holds congresses at two-yearly intervals and symposia on special subjects from time to time.

The Institution of Civil Engineers has set up a British National Committee to organize a British Section of the Association and to co-ordinate and encourage participation by engineers and scientists in Great Britain in the congresses and other activities of the Association. The committee are drafting a constitution for the British Section, in which it is proposed that meetings may be organized in Britain for the discussion of topics of interest to members of the Section.

The committee wish to call attention to the existence and activities of the Association; to seek new members in order to stimulate hydraulic research in Britain; and to ensure that the British Section is well supported. A memorandum giving details of the Association and application forms for membership are obtainable from the Secretary, British Section,

International Association for Hydraulic Research, c/o The Institution of Civil Engineers, Great George Street, London S.W.1.

TEACHING AIDS

A CONFERENCE and exhibition of teaching aids, entitled 'Successful instruction', organized by the British Association of Commercial and Industrial Education, will be held on Wednesday, 31st May 1961, at County Hall, London S.E.1, from 9.30 a.m. to 9 p.m., with a special evening session at the Royal Institution, 21 Albemarle Street, London S.W.1, from 6 to 7.15 p.m. The conference and exhibition are designed for technical-college lecturers and instructors from industry, and represent B.A.C.I.E.'s contribution to the Commonwealth Technical Training Week.

The morning conference session at County Hall will be devoted to closed-circuit television, and in the afternoon a modified version of Dr. H. A. Thomas's 1958–59 Faraday Lecture 'Automation' will be presented. An open forum will close the conference sessions.

In the evening, Sir Lawrence Bragg will arrange a special demonstration of the techniques used at the Royal Institution for teaching scientific principles.

The exhibition at County Hall demonstrating teaching aids will remain open until 9 p.m. for the benefit of teachers, lecturers and instructors who are unable to attend during the day. No charge will be made for admission after 5 p.m. A programme of education and training films will be screened from 11.30 a.m. to 1 p.m. and from 5 to 8.45 p.m.

For the exhibition and conference at County Hall there is a conference fee of 15s. and for the special evening session at the Royal Institution a fee of 5s. Further information may be obtained from the Association at 26a Buckingham Palace Road, London S.W.1.

ESSAY COMPETITION

THE publishers of *Research* invite entries for their 1961 Waverley Gold Medal essay competition. The medal and £100 will be awarded for the best essay of about 3000 words on a new project or practical development in pure or applied science. Essays should be written to interest a well informed layman. A second prize of £50 will be awarded, and also a special prize of £50 for the best entry from a competitor under the age of 30.

The last date for the receipt of entries is the 31st July 1961. Entry forms will be supplied on application to *Research*, 88 Kingsway, London W.C.2.

INDUSTRIAL ELECTRONICS

A SYMPOSIUM on industrial electronics will be held on the 20th and 21st September 1961 in the Bradford Hotel, Boston, Mass., U.S.A. It will be sponsored by the Institute of Radio Engineers Professional Group on Industrial Electronics, the American Institute of Electrical Engineers and the Instrument Society of America.

Sessions of the symposium will cover measuring techniques, digital and analogue methods, and new power-conversion systems.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E ELECTRONICS AND COMMUNICATIONS SECTION
M MEASUREMENT AND CONTROL SECTION
U UTILIZATION SECTION

The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

May 1961

E **17** *Wednesday* E. EASTWOOD, PH.D., M.SC., *and* B. J. O'KANE, PH.D., B.ENG. Lecture on 'Air-traffic control'†

18 *Thursday* ANNUAL GENERAL MEETING *followed, at approximately 6.30 p.m., by* J. A. RATCLIFFE, C.B.E., M.A., F.R.S. Lecture on 'Experimental investigation of space'‡

U **25** *Thursday* J. A. BROUGHALL, B.SC.(ENG.). Annual Lecture. 'Electric traction'‡

29–2 June *Monday–Friday* Summer Meeting in London

June 1961

EM **12–16** *Monday–Friday* International conference on components and materials used in electronic engineering (see p. 300; all wishing to attend are required to register; forms are available on application to the Secretary of The Institution)

† An abstract will be available in advance
‡ No advance information will be available

O.E.C.C. MISSION

A MISSION sponsored by the Organisation for European Economic Co-operation is touring the United States in order to study economic and technical aspects of interconnected Grids and power-pool operation. The United Kingdom is represented by the Chairman of the Electricity Council and four other delegates. The project follows the Tecaid Mission to the United States in 1949 and the return visit to Europe in 1956.

The itinerary of the party includes the Edison Electric Institute in New York, the hydroelectric scheme at Niagara Falls, the Eddystone thermal power station in Philadelphia and the Enrico Fermi atomic power plant near Detroit.

RADIATION REGULATIONS

THE 'Ionizing radiations (sealed sources) regulations' have been published as a Statutory Draft by the Ministry of Labour under the Factories Act of 1937. The regulations impose requirements for the protection of persons employed in factories and other places to which the Factories Act applies against ionizing radiations arising from sealed sources, and machines or apparatus intended to produce ionizing radiations or in which charged particles are accelerated by a voltage of not less than 5kV.

A complementary draft code 'Unsealed radioactive substances regulations' has been prepared by the Ministry with help from an *ad hoc* expert committee appointed to advise the Chief Inspector of Factories on the subject, the Advisory Panel on Radiological Problems in Industry, and the General Purposes Sub-Committee of the Radioactive Substances Advisory Committee, and has now been published as a Preliminary Draft.

The regulations impose requirements for the protection of persons employed in factories and other places to which the Factories Act of 1937 applies against unsealed radioactive sources.

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

THE CONTROL OF CONTROL

On the 21st March 1961, a cheerfully youthful audience completely packed the Lecture Theatre at Savoy Place to discuss 'Self-adaptive control systems'. Evidently, the idea of 'controlling controllers' intrigues the younger generation, who now regard plain feedback as nursery stuff.

Four openers were listed, and Dr. J. H. Westcott led off by heroically plunging into backward-operating dynamic programming and by an even more breathtaking excursion into statistical dynamics. Precisely how this related to self-adaptive control systems was, we presumed, clear to Dr. Westcott. He enlivened the mathematics with witty asides and, on concluding, was very properly given the applause due to a toreador at a bullfight.

Fortunately, perhaps, the remaining openers had less to say about abstract theory but described actual experimental examples of control systems in which some progressive modification automatically maximized performance—assuming performance to correspond with some defined function of measured quantities. Dr. J. L. Douce described basic models of this kind, and concluded by showing a short film in which an actual physical 'hill' was climbed by a probe that sensed the direction of upward slope. It was a great moment when his robot, after much wandering, finally—so to speak—waved the Union Jack from the summit.

Hill-climbing

Mr. P. H. Hammond described developments in progress at the National Physical Laboratory, which he explained as 'automatized trial-and-error control'. He produced very revealing slides showing the routes taken towards the maximum. Unfortunately, Dr. P. E. W. Grinsted was unable to be present, but Mr. Jacob, one of his collaborators, described somewhat similar work in progress at Cambridge.

A spirited discussion followed. Dr. Florentin very usefully called attention to the gulf to be bridged between these laboratory and analytical efforts, and the application to such intractable monsters as chemical plants; but Mr. Allen briefly described successful application, on very simple lines, to a distillation column. A number of contributors pointed out difficulties that occurred when a 'hill-climber' insisted on planting the flag on a minor, rather than a major, summit or on a pseudo-summit, owing to a barrier or limit.

Prof. A. Tustin, who was in the chair, in thanking the openers for their contribution, said that it was evident from this large and enthusiastic gathering that self-adaptive control systems would soon be more than an intriguing concept and would mark an important next stage in the evolution of control systems.

A. T.

SUPPLY

DEPRECIATION THEORY CHALLENGED

All too rarely do we have a paper presented to The Institution that provides the setting for a wordy affray into which accountants, economists *and* engineers can throw themselves with an unholy fervour. But the paper presented by Mr. D. Rudd at Savoy Place on the 15th February 1961—'A general theory of depreciation of engineering plant'—did just that, though the author must have gone home with the impression that we were a poor lot—unbelievers, unreceptive to new ideas!

The paper, however, invited challenge, and this word was used so extensively in the course of the discussion that at one stage the Chairman, Mr. J. E. L. Robinson, invited 'the next challenger to sign in'.

Two statements in the paper were sufficient by themselves to spark off the attack—the opening sentence of the summary, which implied that the author's theory contained no arbitrary features, and the claim in the opening sentence of the conclusions that the theory was 'derived' rather than stated. A short review of the paper appears on p. 302.

Then the deluge

In the onslaught which began at once, accountant and economist alike were at pains to point out to the author the difference between depreciation as such and depreciation provisions—two altogether different things, each requiring its own proper approach. As they warmed to their task, we listened with respect while they portrayed the importance of such matters as financial prudence, the true life of plant, the

seemly statement of profits, the arbitrary factors ('only total depreciation is actual'), the tax laws, the distinction between commitments and avoidable cost, and so on.

Interspersed with the financial experts came the engineers with somewhat more earthy contributions to the discussion, though they also were critical of the theory. One engineer commented that the author's proposals would involve the replacement of the new nuclear power stations by conventional ones before they were even in service! Another called attention to the way in which, throughout his whole lifetime, railway electrification had been held up by economic argument.

In a spirited reply, the author said that he was offering a method that sought to make accounts conform with reality. The Chairman described it as 'a brave excursion'. D. B. I.

ANOTHER SUCCESS STORY

WITHOUT being repetitive it is difficult to find adjectives when endeavouring to describe the happy and successful Annual Dinner-Dance, which members of the Section strongly support. The function on the 9th March 1961 proved no exception, but unfortunately the Chairman, Mr. J. E. L. Robinson, could not be accompanied by his wife, who was indisposed. Mrs. Mortlock gracefully supported him at the reception.

In a short speech between dining and dancing, the Chairman, in welcoming members of other Sections and visitors, referred to the pleasure given to those present by the attendance of the President, Sir Hamish D. MacLaren, and Lady MacLaren. He revealed that Mr. T. B. D. Terroni, now of electronic persuasion, had 'heavy' foundations, Mr. J. K. Webb, although given to measurement, was not without large-power cable connections, and Dr. W. G. Thompson of the Utilization Section was a close professional relation.

Sir Hamish, exclaiming that his year of office seemed to be slipping by quickly, indicated the pleasure accorded him in being present at the last of such functions in a memorable period. In expressing the appreciation of the visitors, he aptly coupled this with a reference to the feared dour results of a failure (fictitious) of the supply system in the Highlands. From reception to 'Auld lang syne' the evening sped pleasantly away, making another success story. F. C. W.

ELECTRONICS AND COMMUNICATIONS AND SUPPLY

THE ENGINEERING ASPECTS OF PLASMA PHYSICS

AT the joint meeting of the two Sections on the 22nd March 1961 at Savoy Place, Messrs. R. Carruthers and D. L. Smart expounded lucidly, in a very interesting lecture before an attentive audience, the wide range of the large and complex engineering problem associated with the design of the research equipment to achieve a controlled thermonuclear reaction (c.t.r.). The ultimate purpose of such work is to develop a technique for generating electric power from the release of atomic energy by the controlled fusion of suitable light atomic particles.

The basic material used as a fuel is deuterium, an isotope of hydrogen (its chemical combination with oxygen is known as heavy water). Controlled fusion of deuterium nuclei, i.e. of deuterons, should be obtained at temperatures of the order of 10^6°C, such fusions producing either helium 3, an isotope of helium, or tritium, an isotope of hydrogen; in both cases energy is released. The basic practical problems are twofold: first, how to heat the plasma of deuterons to a temperature higher than that of the sun; and secondly, how to keep the hot plasma from physical contact with the walls of the vessel.

Present solutions

A solution with a closed-type system of plasma containment has been employed, for example in Zeta at the Atomic Energy Research Establishment at Harwell. The plasma forms the single-turn secondary of a high-power pulse transformer into whose primary the stored energy of a large capacitor bank is discharged, causing in the plasma a flow of current of such magnitude that the plasma becomes heated and also that the resultant magnetic field forces the cross-section of the plasma to contract (pinch effect) and thus forces the plasma to be isolated from the walls of the vessel.

Other solutions are based on an open-loop system employing, for example, a magnetic-mirror principle in which a pinch effect is combined with a back-and-forth motion of the particles.

The lecture made it clear, and this was amplified in the subsequent discussion, that the work and problems described were concerned only with the first step towards achieving electric-power generation from c.t.r. and that no rash or easy solution was to be expected for quite a time to come. It became also clear that any approach to the practical problems of work on c.t.r. required the combination of the outlook of the electronics and communications engineer with that of the designer of equipment for the supply industry, but with a particular stipulation: that the experimental switching equipment was to be designed to give a lifetime of about 10^6 operations.

Mr. T. B. D. Terroni, Chairman of the Electronics and Communications Section, presided, and Mr. J. E. L. Robinson, Chairman of the Supply Section, proposed a hearty vote of thanks to the lecturers. R. F.

ELECTRONICS AND COMMUNICATIONS

BACK-SCATTER SOUNDING IN THE H.F. BAND

At Savoy Place on the 6th March 1961, Mr. E. D. R. Shearman presented his paper 'An investigation of the usefulness of back-scatter sounding in the operation of h.f. broadcast services'. This paper is reviewed on p. 306. The meeting was well attended for one on a specialist subject, and the subsequent discussion indicated the wide interest among those present. Mr. J. A. Ratcliffe was in the chair.

The lecturer stated that back-scatter sounding was the application of the radar technique to the h.f. band to study the modes of propagation. In contrast with radar, the primary purpose was not to determine the locations of targets but to find which parts of the Earth were illuminated by ionospheric reflection of the transmitted radio waves. The objects of the experiments described were to find, by pulse-sounding, the locations of the illuminated zones by back-scatter observations and to study the extent to which the echo-patterns gave a guide to the variation of field strength along the transmission path.

The author illustrated the results of his tests using 1ms-pulse transmissions originating from the B.B.C.'s Rampisham transmitter and received at the Radio Research Station, Slough; also on 120μs-pulse transmissions which originated and were received at Slough.

The radiation characteristics of the transmitting and receiving aerials were illustrated, and their contribution to the echo characteristics was explained. A number of range/amplitude echo-patterns were shown that illustrated the usefulness of the technique. Echoes were observable on some of these patterns at distances of 8000km. These tests were correlated with signal-strength measurements at points along the transmission path.

The work demonstrated the practical use of scatter sounding, both as an engineering tool and for finding the most effective frequency and the most suitable aerial system for the communication path. It offered advantage over vertical-incidence sounding and oblique-path prediction because it gave an instantaneous indication of the propagation conditions.

Why not sooner?

During the discussion, one speaker commented that it was surprising that the back-scatter technique of ionospheric sounding had not yet come into commercial practice, although early experiments had demonstrated its feasibility nearly ten years ago. It appeared that the back-scatter-sounding technique was exceedingly useful, since information on the propagation conditions could be obtained without co-operation from the distant station.

In this connection the application to aeronautical-communication services was important, because an aircraft in flight needed to use frequencies that were chosen as the most favourable for the path over which it had to communicate. Mention was made of trials which were proceeding in conjunction with British Overseas Airways Corporation and a back-scatter sounder at Birdlip belonging to the Ministry of Aviation.

Another speaker mentioned that his company had just come through three months of poor radio-circuit performance over long-distance services. In general it was not difficult to maintain communication for about 20 hours out of 24 by using the well established frequency-prediction techniques, but to make good the remaining four hours, scatter sounding might be useful because it was an instantaneous method of measurement.

Another speaker thought that perhaps some of the information on the back-scatter display might have originated from behind the aerials, but Mr. Shearman replied that at Slough he had taken great care to obtain a good front-to-back ratio on the aerial system.

Comment was made on the complexity of the equipment and the degree of skill required for operation and for interpretation of the results, and it was suggested that simpler equipment would make its use more attractive at communication stations where highly skilled staff were not necessarily available. The discussion continued at length on many significant aspects of the technique and provided those present with an interesting meeting. C. W.

ULTILIZATION

CARGO-DOCK REQUIREMENTS

The paper read at the meeting on the 9th February 1961 at Savoy Place was 'Some notes on the electrical requirements of general cargo docks', and in presenting it, the author, Mr. E. R. Radway, pointed out that it had been written with special reference to the South Wales ports. In the course of his remarks he covered very comprehensively such matters as power supply and distribution, pumping, lock-entrance machinery, mechanical-handling problems, lighting requirements and the organization of maintenance. The paper is reviewed on p. 304.

Mention must also be made of the very neat and brief definition given in the paper of 'a dock', which, it was said, 'provides a safe anchorage in conjunction with rail- and road-heads having storage accommodation and mechanical facilities for efficient cargo-handling'.

The author broke with the usual tradition of replying to

all the points raised at the end of the discussion by electing to reply after each individual contributor had spoken—a practice which seemed to have certain advantages in that the discussion was thereby kept continuously stimulated throughout its entire length.

Conclusions first

The discussion was opened by Mr. J. Monkton who, in disagreeing with the use of overhead lines in dock areas, said that his experience was that 'almost anything you put up, someone can knock down'. It was refreshing to hear one speaker, in prefacing his remarks, openly confess that he always read the conclusions of a paper first, as this saved a lot of time.

The author, in replying to some comments on crane control gear, said most emphatically that there were some he would not have at any price! It certainly was interesting to hear from another speaker that experience in the London docks had shown that battery-operated trucks had proved far more economical to use and maintain than Diesel trucks.

The Chairman, Mr. J. M. Ferguson, in according on behalf of all present a well deserved vote of thanks to the author for his excellent paper, made reference to his particular brand of humour, which had been in evidence throughout the proceedings and had been much appreciated by all, contributing in no small measure to the success of the meeting.

R. H. R.

News from the Centres

NORTH MIDLAND CENTRE

Annual Dinner-Dance

THE Annual Dinner-Dance of the Centre took place on the 3rd March 1961 at the Cairn Hotel, Harrogate. It proved a most successful occasion, and we were honoured by the presence of Sir Hamish D. MacLaren, President of The Institution, and Lady MacLaren, and Mr. W. K. Brasher, Secretary of The Institution, and Mrs. Brasher.

At the North Midland Centre Annual Dinner-Dance on the 3rd March 1961

Seated (left to right): Mrs. W. K. Brasher, Lady MacLaren, Mrs. F. W. Fletcher and Mrs. G. W. Carter

Standing (left to right): Mr. J. Woodhouse, Mr. F. W. Fletcher, Mr. W. K. Brasher, Mrs. J. Woodhouse, Mrs. W. J. A. Painter, Sir Hamish D. MacLaren, Prof. G. W. Carter and Mr. W. J. A. Painter

The amount realized from the prize draw in aid of the Benevolent Fund this year was a record and, after adding several donations, the sum given amounted to 200 guineas.

J. W.

SCOTTISH CENTRE

Edinburgh Dinner

THE Edinburgh Dinner was held in the Adam Rooms on the 16th March 1961, when about 170 members and guests assembled under the Chairmanship of Mr. R. B. Anderson. It was an even more enjoyable occasion than usual, the standard in speechmaking being set by Lord Milligan, who proposed the toast of The Institution and, in theatrical parlance, had his audience 'rolling in the aisles' from the moment he rose.

Lord Milligan gave us a definition of electricity, made reference to the 'telegraph boys' from whom The Institution had descended, revealed hitherto unsuspected facts about the organization of the Centre and, finally, when he realized that his toast was to be replied to by the Engineer-in-Chief of the Post Office, could not resist some extremely diverting remarks about the behaviour of his telephone and also of 'Ernie'.

In replying to the toast, Mr. A. H. Mumford, a Vice-President of The Institution, rose nobly to the occasion and, having apparently scrapped his no doubt carefully prepared notes, gave back as good as he had received.

British kindness

As is customary at the Edinburgh Dinner, a short address was given by the Chairman of one of the Graduate and Student Sections, on this occasion Mr. U. E. O. Uchenyi, Chairman of the North Scotland Graduate and Student Section; with the characteristic jolly smile of the Nigerian, Mr. Uchenyi referred to the fact that this was the tenth anniversary of his Section and thanked Maj. W. M. Mackay, the Centre representative on the Section Committee, for his never-failing help and encouragement throughout the whole of this period.

Mr. Uchenyi also expressed his great appreciation of the kindness that he had received in this country and of the

opportunities afforded by the activities of the Graduate and Student Section of meeting so many colleagues having similar interests and ambitions to his own, opportunities that were, as yet, difficult to come by in his own country.

The toast of the guests was proposed by Mr. I. S. Fraser, Chairman of the South-East Scotland Sub-Centre, who found appropriate words for each of the principal guests, particularly Lord Milligan who he suggested was adept at giving short speeches and long sentences and, as a consequence of his membership of the Queen's Bodyguard of Archers, at drawing the long bow. Mr. C. H. A. Collyns, President of the Association of Mining Electrical and Mechanical Engineers, Lothians Branch, and a Past-Chairman of the Centre, replied.

The formal proceedings concluded with a toast to the Chairman, proposed by Mr. W. L. Kidd, Chairman of the South-West Scotland Sub-Centre, and a reply by Mr. Anderson, who thanked the new Honorary Secretary, Mr. David Rollo, for having organized so successful a function.

The Faraday Lecture

The Scottish presentation of the Faraday Lecture took place this year at the Usher Hall, Edinburgh, on the 21st March 1961, when an audience of nearly 2000 heard Mr. L. J. Davies speak on 'Transistors and all that'. The Lecture, although approaching the end of its tour, was delivered with the same ease, lucidity, enthusiasm and perfect stage management as in the earlier presentations. It subsequently transpired that the Scottish Centre had been the only one to express serious concern about the intrinsic value of the transistor-radio unit so nobly swallowed by Mr. Mills and to wish to put in hand immediate steps for its recovery.

In thanking the author, Dr. D. A. Allen, Director to the Royal Scottish Museum, referred to the many and varied entertainments that had been given in the Usher Hall, few of which, he said, could have equalled in clarity of presentation and the resulting obvious enjoyment of the audience this Faraday Lecture as presented by Mr. Davies. E. O. T.

WESTERN CENTRE

Air-gaps

A VICE-PRESIDENT of The Institution, Mr. G. S. C. Lucas, was present on the 13th February 1961 when Mr. G. W. Bowdler presented his joint paper 'The surge flashover voltages of air-gaps associated with insulators and bushings'. Mr. E. H. Jewell opened the discussion, and this was continued by Mr. L. Locker and Mr. J. F. Wright. The vote of thanks was proposed by Mr. P. D. Hanstead who had, that evening, been welcomed as a Corporate member.

Electronic computers

On Wednesday, 15th March 1961, a District Meeting was held at Chippenham when Mr. H. McG. Ross lectured on 'New methods of exploiting electronic computers in the engineering industry'. The lecture was based on the author's article published in the October 1960 *Journal*, but had been modified and extended to include some details of machine-tool control by punched and magnetic tape. The lecture included the presentation of a colour film illustrating these systems.

The talk proved to be most interesting, and the lively discussion that followed, under the chairmanship of Mr. R. W. Steel, was eventually wound up by a cordial vote of thanks to the speaker, proposed by Mr. W. E. Wilkins. The meeting was convened by Mr. R. W. Maltby.

Annual Dinner-Dance

The Annual Dinner-Dance was held at the Grand Spa Hotel, Bristol, on the 24th March 1961, with the Centre Chairman, Mr. A. C. Thirtle, presiding. The official guests included Lord and Lady Citrine, Sir Hamish D. MacLaren, President of The Institution, Sir William Grant, and the chairmen of the local branches of our sister institutions. A record number of 280 members and their ladies attended.

Mr. Thirtle thanked all the members for their wonderful support of the function and said that it was his personal pleasure to welcome Lord and Lady Citrine, whom he had known for over 20 years.

The toast of The Institution was proposed by Lord Citrine, who recalled that in his youth he had had the utmost reverence for The Institution and that this had remained with him. When Chairman of the British Electricity Authority he had had the pleasure of inspecting the experimental records of Michael Faraday and had been impressed by the neatness and precision of the father of our profession.

Lord Citrine continued by stating that 73 women on the rolls as Chartered Electrical Engineers augured well for the profession, and he hoped that these numbers would be augmented. He wished to join Sir Willis Jackson in affirming that The Institution set a standard for the country as a whole. He concluded by recounting that the electrical industry had exported some £300 million worth of electrical goods and that the industry was a vital factor in our national economy.

In responding to the toast, Sir Hamish recalled that he and Lord Citrine were on common ground, inasmuch as one had

Bristol Evening Post

'Conversation piece' at the Annual Dinner-Dance of the Western Centre on the 24th March 1961

electrical connections with ships in Birkenhead and the other with submarines at Chatham.

Need for unity

Sir Hamish stressed the amount of hard thinking that had been devoted to the specialized Sections of The Institution and that a bold and imaginative approach was necessary. Changes had to be approached realistically in the light of modern requirements. He then proceeded to emphasize that, while no fragmentation of The Institution could be countenanced, nevertheless the time was now ripe for ourselves and our sister institutions to take joint action to present themselves to the country where the interest of the profession as a whole was concerned. This was of the utmost importance now that engineering played such a vital part in our nation's economy and even survival.

Mr. T. Gill, Vice-Chairman of the Centre, proposing the toast of the guests, gave his hearty congratulations to Sir Hamish on being elected to the highest position in The Institution and coupled with this the many years of devoted service that Lord Citrine had given to the industry. Mr. W. K. Brasher was an especially welcome guest, and he was glad to express publicly his appreciation of the work that had done so much for The Institution. He also welcomed all other guests to this function.

Councillor C. O. Worth, Chairman of the Bristol Docks and Harbour Board, responding, thanked the Chairman on behalf of the guests for inviting them to such an enjoyable evening and concluded by stating that the electrical industry was now so complex that at times he wistfully wondered just who supplied the vast quantities of electricity that were used by the Harbour Board. This doubt, he felt sure, also was felt by many of the guests present.

In his inimitable manner, Mr. A. H. McQueen continued during the dance to charm, with outstanding success, all available moneys from the members on behalf of the Benevolent Fund. E. J. M.

Fine camera work

The Supply Group of the Centre held a meeting in Bristol on Monday, 20th March 1961. The Section Chairman, Mr. J. E. L. Robinson, was present.

The theme of the meeting was a talk by Mr. D. Longman on the construction of the Hinkley Point nuclear generating station. A collection of colour slides illustrated the whole of the talk; they were the best colour slides that had ever been screened in Bristol.

During the meeting, a presentation was made to Mr. Alec Beckingsale, who has retired from the Honorary Secretaryship of the Group after eight years of service. The Chairman of the Group, Mr. A. H. McQueen, referred to the posts held by Mr. Beckingsale since his arrival in Bristol and said that the duties of Honorary Secretary had been carried out with the same purpose and distinction as Mr. Beckingsale had applied to the various posts he had held. They were sorry that his services as secretary would be lost but glad that he had undertaken the office of Vice-Chairman.

Mr. Robinson presented Mr. Beckingsale with a camera and its case. The gift was subscribed for by Mr. Beckingsale's many friends in the Centre. A. H. McQ.

LONDON REPORT

JOINT MEETING OF THE THREE INSTITUTIONS

THE SEVENTH GRAHAM CLARK LECTURE

At a joint meeting of The Institutions of Civil, Mechanical and Electrical Engineers in the Great Hall of The Institution of Civil Engineers, Great George Street, London, on the 13th April 1961, H.R.H. Prince Philip, Duke of Edinburgh, delivered the Seventh Graham Clark Lecture on the subject of 'The engineer in Commonwealth development'.

The proceedings were relayed by closed-circuit television to 'overflow' audiences in the Lecture Theatres of the three institutions, so that the total audience was about 2200 including the 780 in the 'Civils' Great Hall.

Sir Herbert Manzoni, President of The Institution of Civil Engineers, welcomed Prince Philip and then asked Prof. Owen Saunders, President of The Institution of Mechanical Engineers, to conduct the meeting. Prof. Saunders spoke of the origin of the Graham Clark Lecture and asked Prince Philip to deliver the Seventh.

A target for the engineer

His Royal Highness began with the words 'Every time I come into this Hall something dreadful happens to me. The first time was to take the entrance examination into the Navy. This time, however, it is you who are sitting in the uncomfortable chairs'. The Prince spoke for an hour, fluently and convincingly, enlivening his text from time to time with shrewd flashes of humour. In concluding, he said that the engineer was the key figure in the material progress of the world. The target we should set ourselves in the Commonwealth was a reasonable material standard for all its people, and the main responsibility for reaching that target would rest on the engineer.

The full text of the Lecture will be published in the June 1961 *Journal*.

Leadership of profound significance

Sir Willis Jackson, moving a vote of thanks to Prince Philip, spoke of the abundant evidence in the Lecture of the Prince's deep interest in science and technology. No one was better fitted to speak about the sociological consequences of progress in science and technology. The Lecturer was exercising a leadership of the most profound significance.

Sir Willis referred to the scheme of lectures for schoolchildren which had stemmed from the Prince's four-year Presidency of the British Association for the Advancement of Science and which had attracted already an aggregate audience of more than 200000. The Prince had conceived the study conference on the human problems of industrial communities within the Commonwealth, held in Oxford in 1956. The forthcoming Commonwealth Technical Training Week that he had inspired would touch young people throughout the world. Professional engineers were determined to ensure a great success for the Week, and in addition they would do all they could to further the broad educational objectives to which the Prince was devoting so much of his time and energy.

Improving standards of life

That evening, drawing on his unique knowledge and experience, the Prince had portrayed, in a survey of quite magnificent breadth, the part that professional engineers had to play in improving the standards of life in the underdeveloped countries of the world, not only as experts in their respective specialities but also as men of broad vision, of sound judgment and of unassailable integrity.

Their gratitude to the Prince was unbounded: first, for all the trouble he had evidently taken on their behalf; secondly, for his achievement in writing that magnificent address while on a world tour, in circumstances and with commitments that must in themselves have been very arduous; and thirdly, because they were deeply honoured by the Prince's presence that evening.

The vote of thanks was carried by acclamation with prolonged applause.

At Savoy Place

This meeting presented the first occasion, since the reconstruction of the Institution building, for bringing into use the extended meeting-room facilities at Savoy Place. The audience there, of about 700 members drawn from the three institutions, occupied the Lecture Theatre and the Faraday Room, which had been linked by the raising of the soundproof partition that ordinarily divides them.

ORDINARY MEETING

POSTGRADUATE TRAINING FOR ELECTRICAL ENGINEERS

AMONG university students, electrical engineers have as hard a course to run as most. It might therefore seem almost sadistic to advocate further labours for those who are most successful in this exacting race. This, however, was the theme of the paper by Mr. N. N. Hancock and Mr. P. L. Taylor, 'The place of formal study in the postgraduate training of an electrical engineer', presented at the meeting at Savoy Place on the 2nd March 1961, with the President of The Institution, Sir Hamish D. MacLaren, presiding. A review of the paper appears on p. 301.

Mr. Hancock explained the need for courses at postgraduate level for a selected minority of young engineers who were destined to be the designers and research workers of the future. After discussing the timing, location and organization of such courses, he defended the choice of an eight-week full-time course, provided by a university engineering department, in the later stages of the two-year postgraduate-trainee period. Such a course had been developed in the Electrical Engineering Department of the Manchester College of Science and Technology, at the instigation of Sir Willis Jackson.

The discussion was disappointing in its dearth of speakers from industry. This general deficiency was redeemed by a particularly lively contribution from a practising industrialist —that of Dr. W. J. Gibbs, as opening speaker—who admitted the need for postgraduate courses but contested many of the authors' theses, including that of an eight-week course for graduate trainees: he favoured shorter courses, probably residential, for more senior men who had the necessary experience to benefit from them.

The educationist's view

The later contributions, from teachers and others in various spheres of educational activity, were interesting, encouraging and helpfully critical. Mr. H. W. French, for example, pointed out that the avenue of work chosen was a significant factor in the timing and extent of the postgraduate training necessary. He instanced control engineering as a field in which almost immediate postgraduate study was desirable and on a fairly extensive scale. He, like others, pointed out the need for a variety of courses and called attention to the contribution that technical colleges, suitably staffed and equipped, could make in this work.

Dr. G. S. Atkinson agreed that postgraduate courses should be postponed for some time after graduation, except possibly for students who had taken a Diploma in Technology course which, if industry-based, would have provided a student with some of the industrial experience necessary to enable him to benefit from such courses.

Mr. Taylor, after cautioning the audience that the authors 'were not as a body responsible for the opinions' he might express, since they had not had the opportunity to consult over them, went on to give an entertaining and vigorous reply to the discussion. He agreed that this course was only one contribution to a large problem and hoped for experiments by others, not merely acceptance of a particular pattern of course. E. B.

[After the London meeting closed, it became known that Dr. Gibbs, who had left early, had become seriously ill. At the time of going to press it is known that he is making good progress towards recovery. Our sincere good wishes go to him for a speedy recovery.—Editor]